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Deng

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(54) **HEATING APPARATUS WITH FAN**

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

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F24B 1/189	(2006.01)
F23L 13/00	(2006.01)
F23L 13/02	(2006.01)
F23C 7/00	(2006.01)
F23D 14/64	(2006.01)
F24B 5/02	(2006.01)
F24C 3/00	(2006.01)
F24C 15/00	(2006.01)
F24C 15/02	(2006.01)

(52) **U.S. Cl.**

CPC ***F24B 1/189*** (2013.01); ***F23C 7/008*** (2013.01); ***F23D 14/64*** (2013.01); ***F23L 13/00*** (2013.01); ***F23L 13/02*** (2013.01); ***F24B 5/026*** (2013.01); ***F24C 3/006*** (2013.01); ***F24C 15/006*** (2013.01); ***F24C 15/028*** (2013.01)

(58) **Field of Classification Search**

CPC F23M 7/04; F24C 15/006; F24C 15/025; F24D 2200/10; F24F 2009/007; F24F 9/00; F24F 13/18; F24F 2009/005

USPC 126/500, 528, 190, 193, 198, 200

See application file for complete search history.

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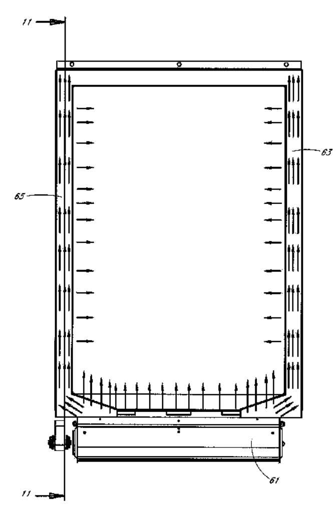
(57) **ABSTRACT**

A heating apparatus can have a sealed combustion chamber and a burner. The heating apparatus can have an air shutter that controls the amount of air that mixes with fuel directed toward the burner. The air shutter can be controlled by rotating a shaft that connects to the air shutter. The heating apparatus can also have a system of channels along its front face which direct air along the front face.

17 Claims, 19 Drawing Sheets



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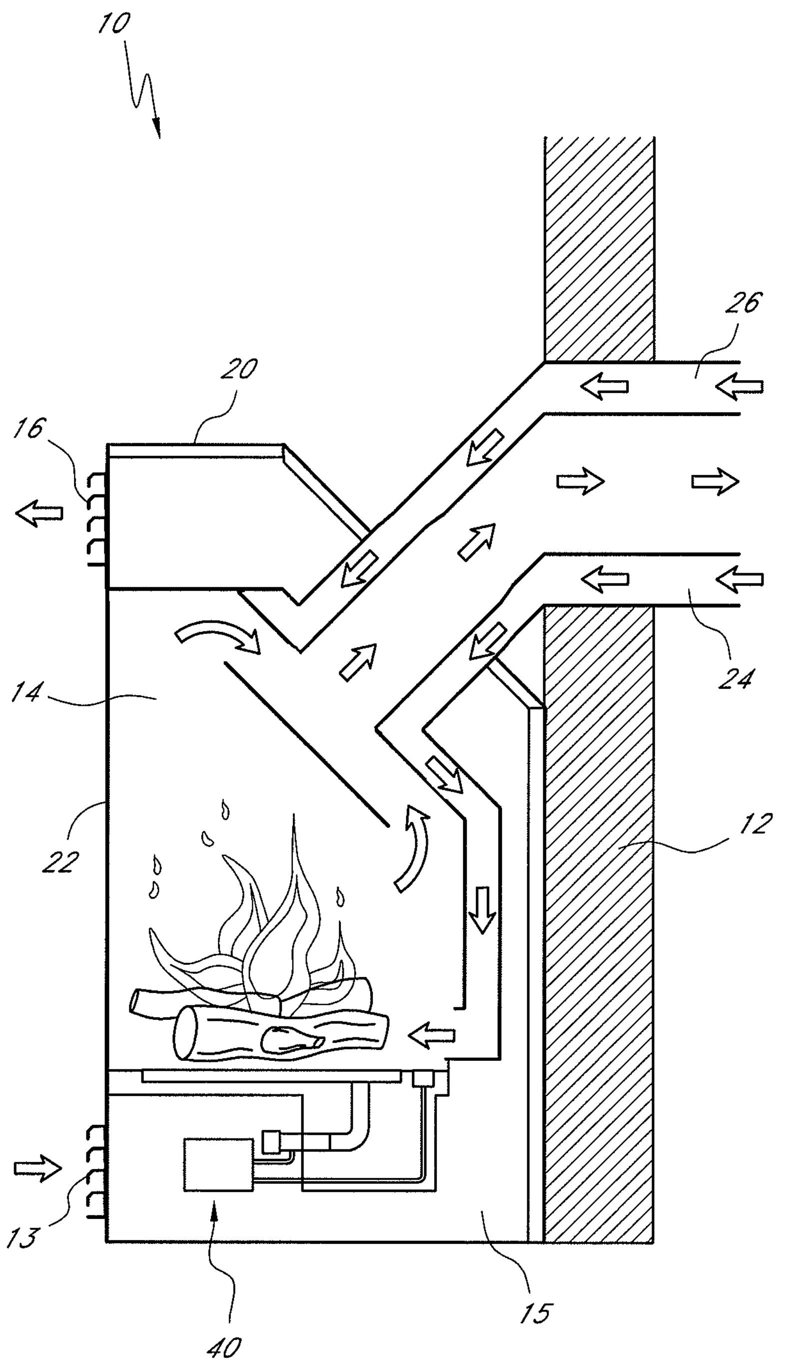

FIG. 1

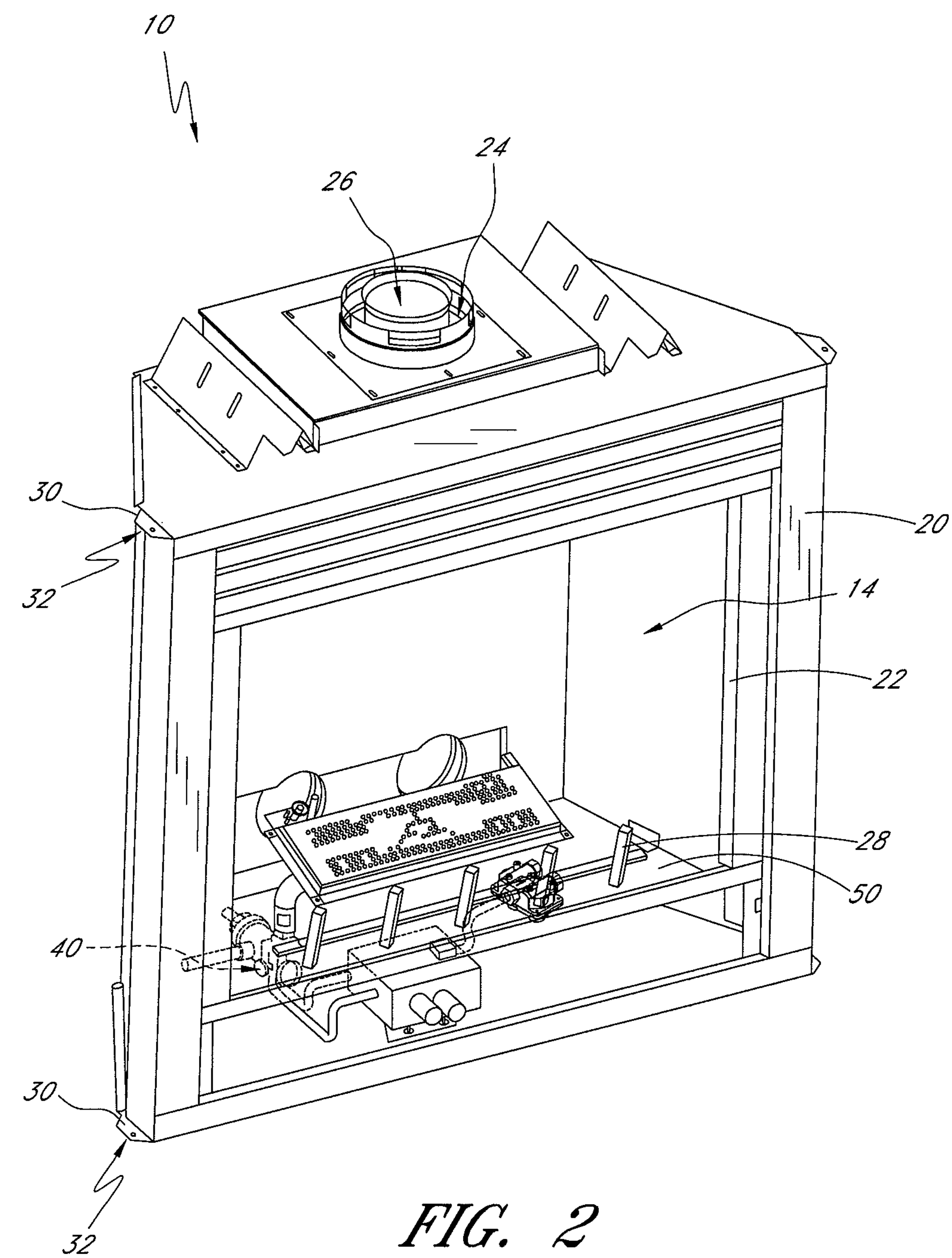

FIG. 2

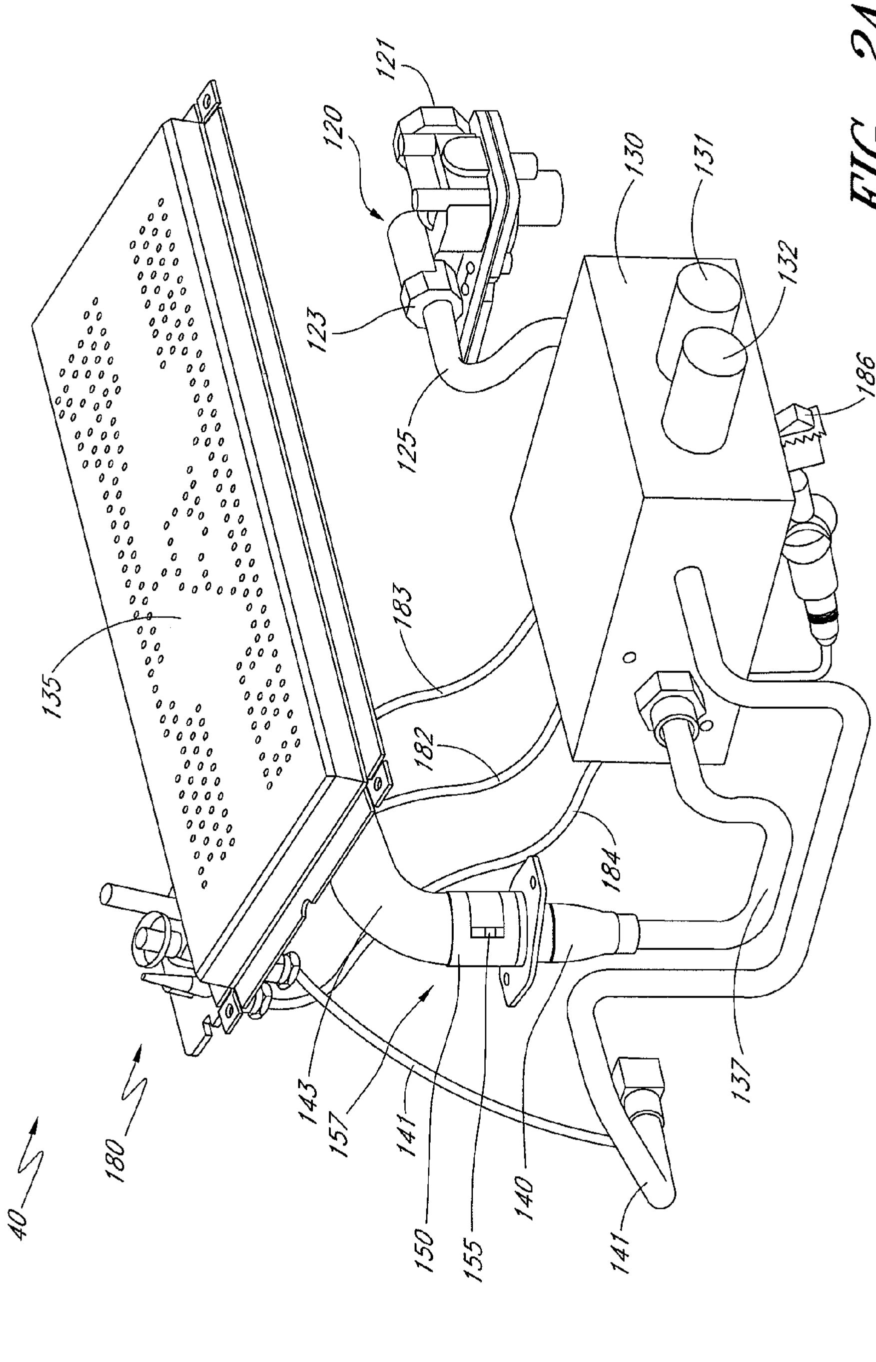
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FIG. 2A

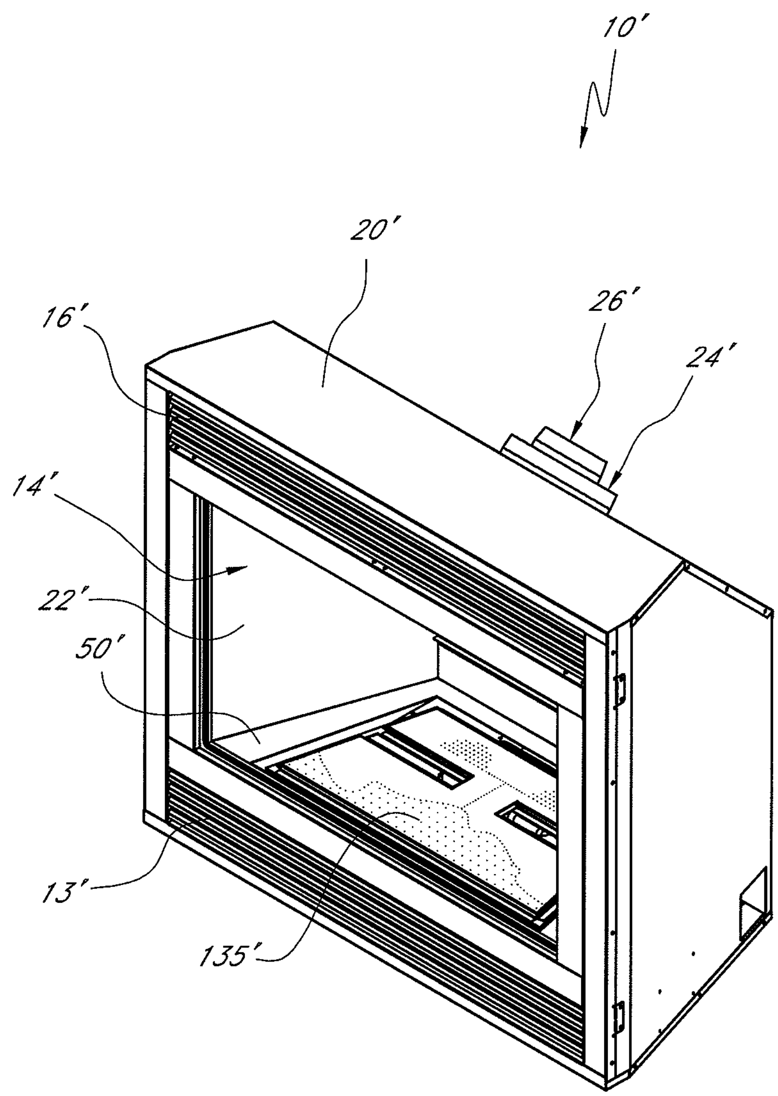

FIG. 3

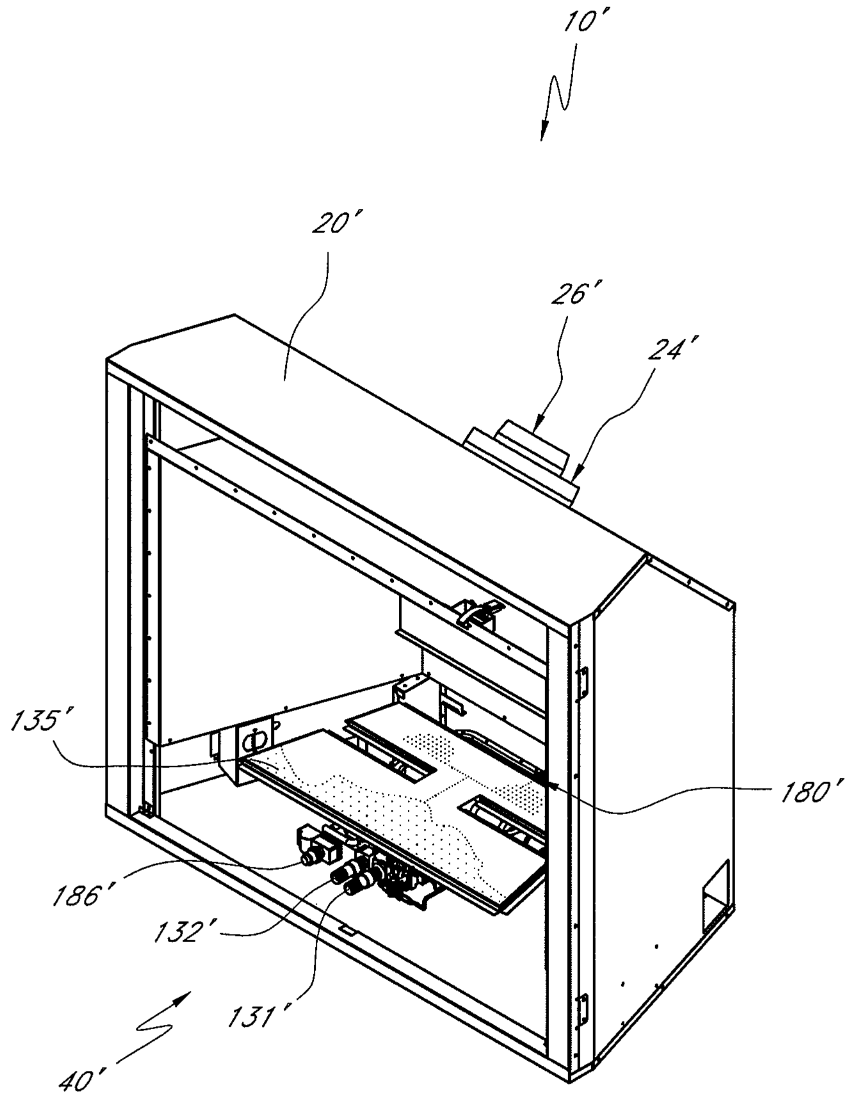

FIG. 3A

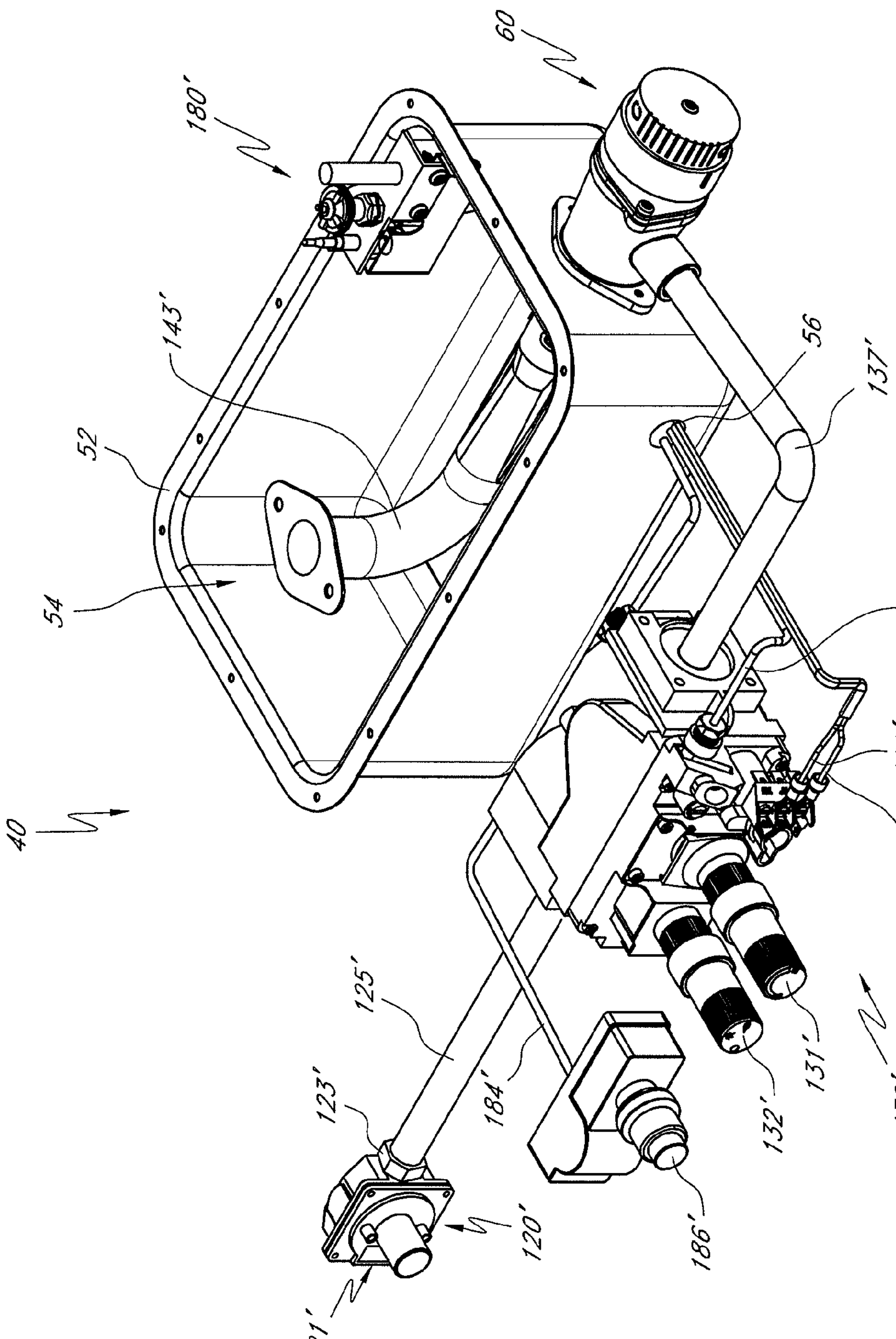
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FIG. 3B

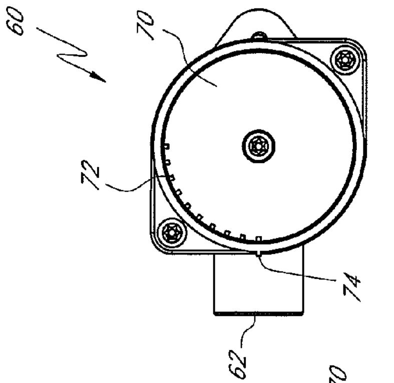


FIG. 4C

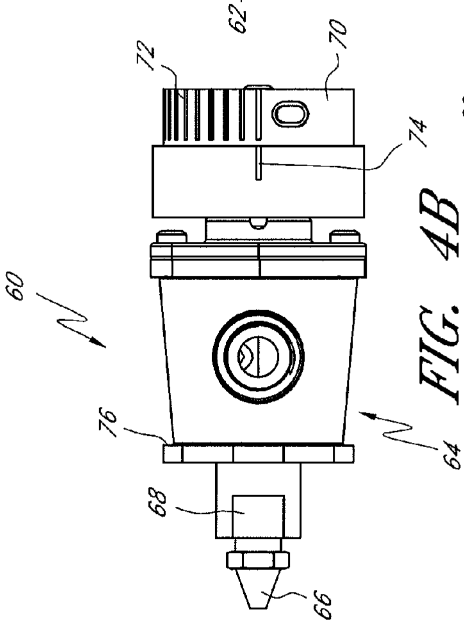


FIG. 4B

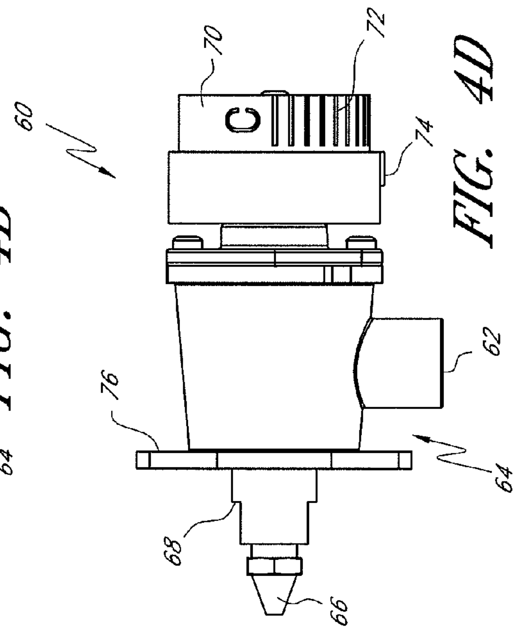


FIG. 4D

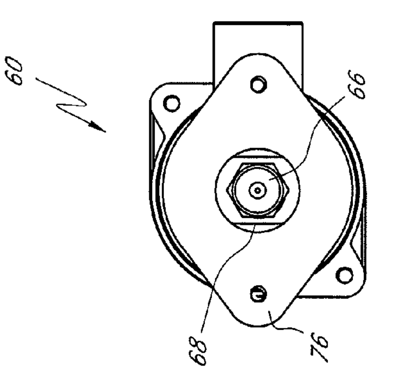


FIG. 4A

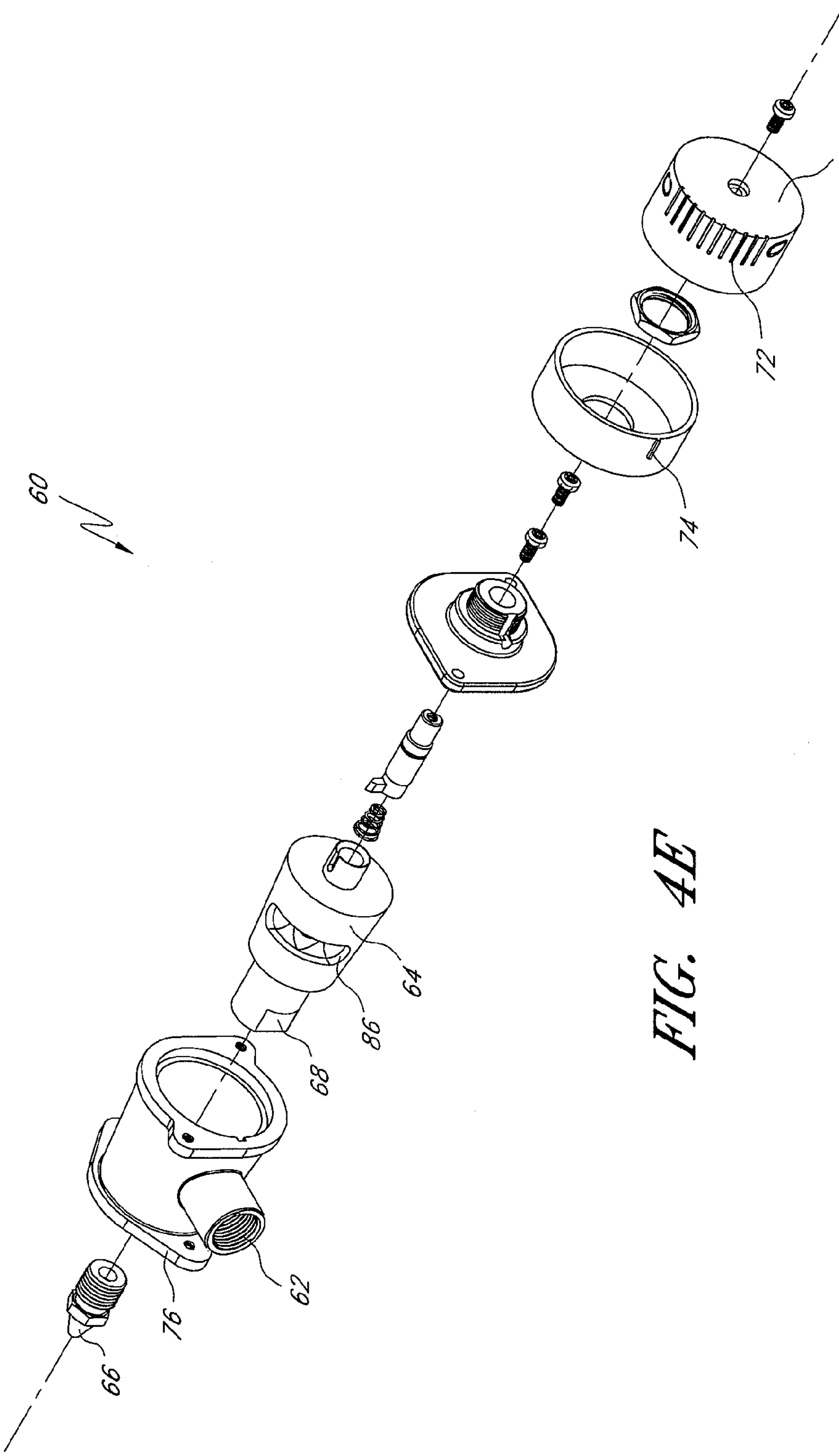


FIG. 4E

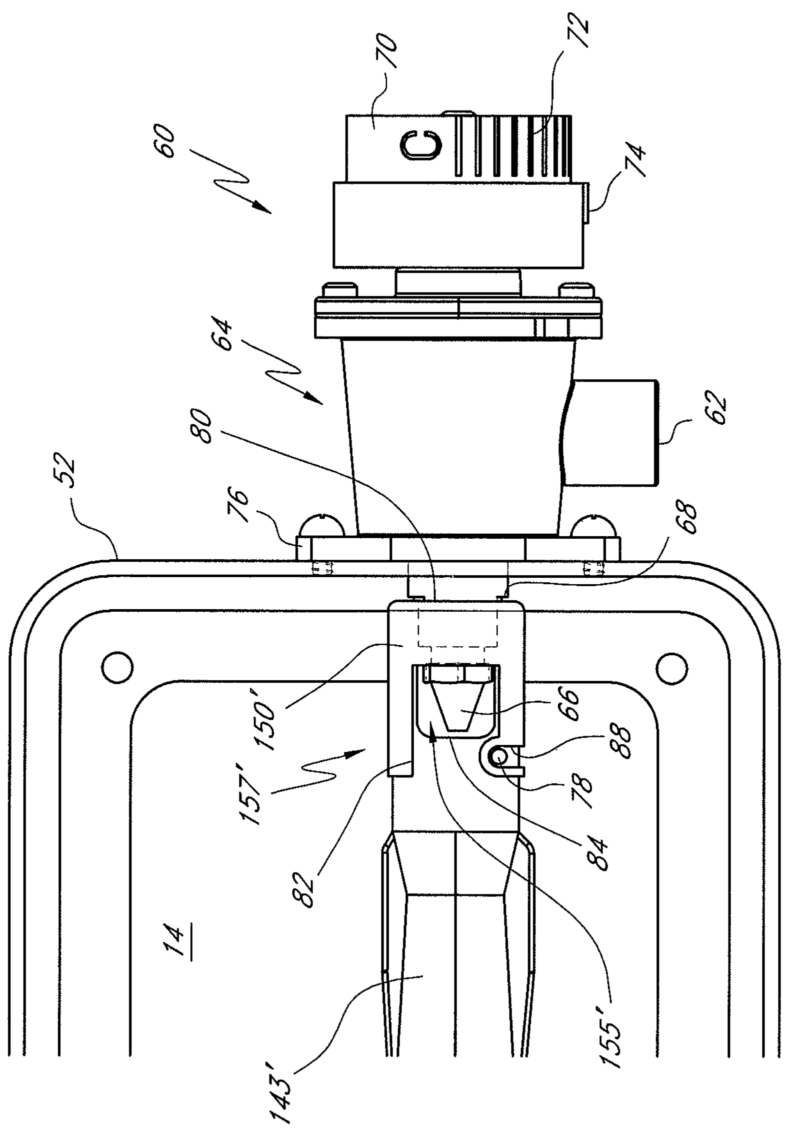


FIG. 5

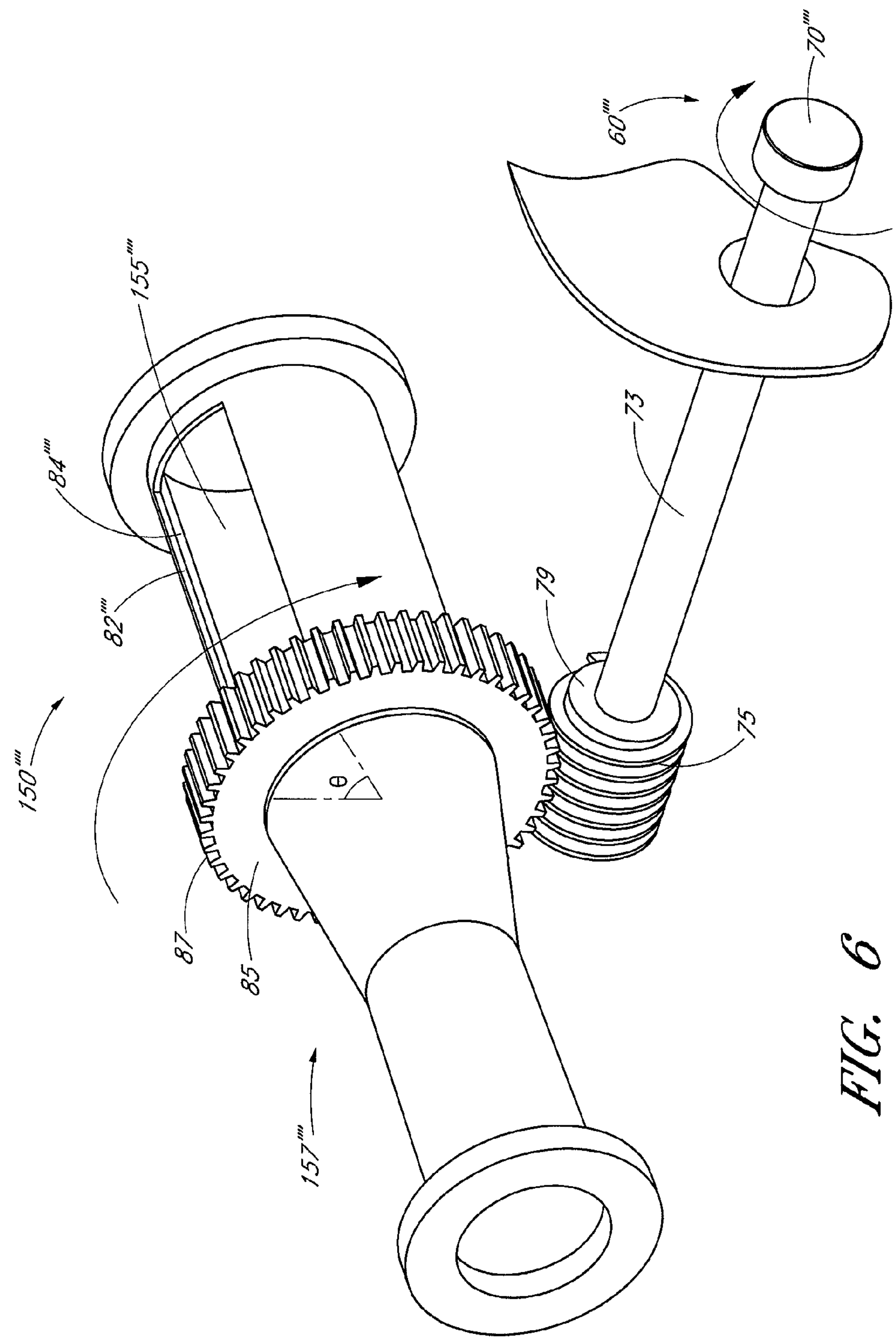


FIG. 6

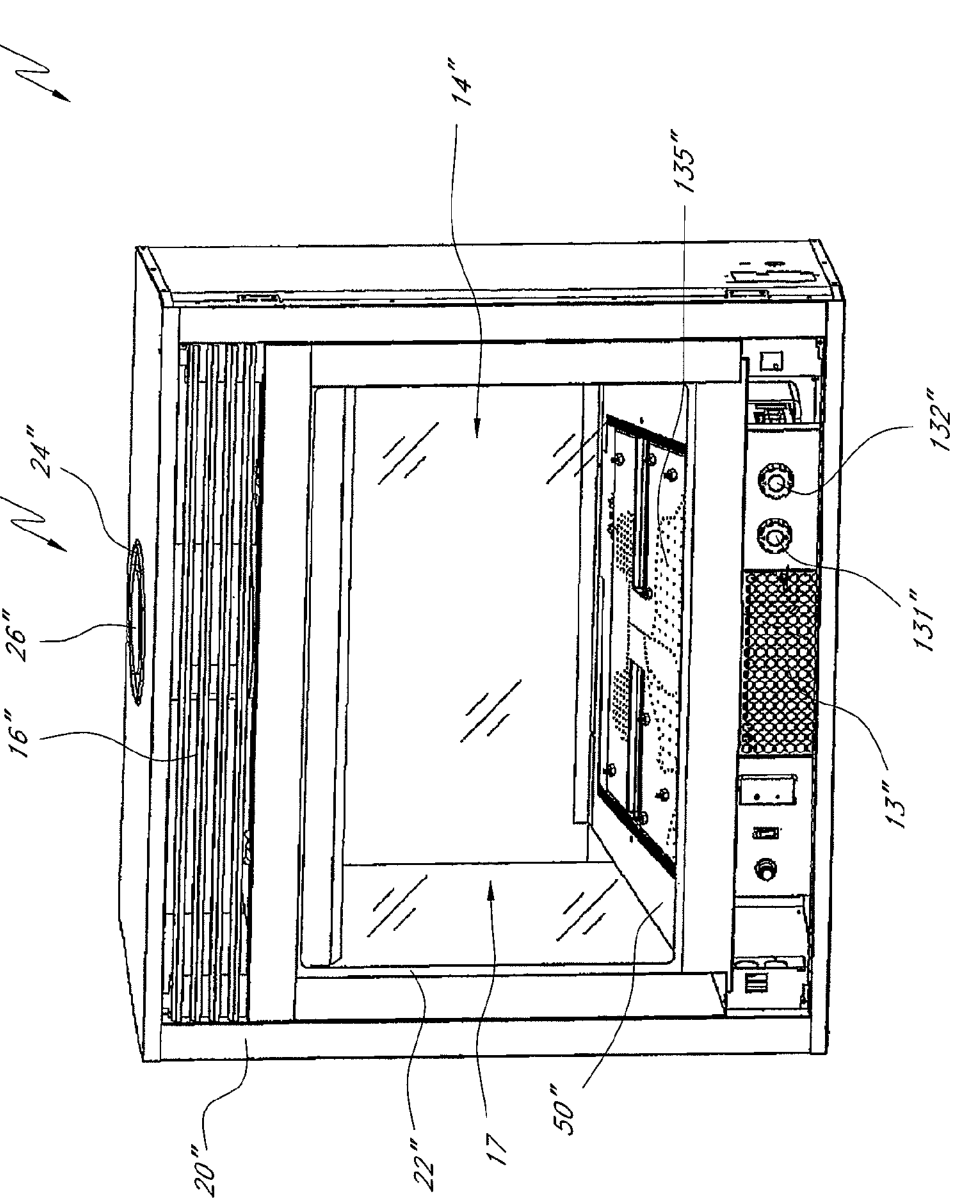


FIG. 7

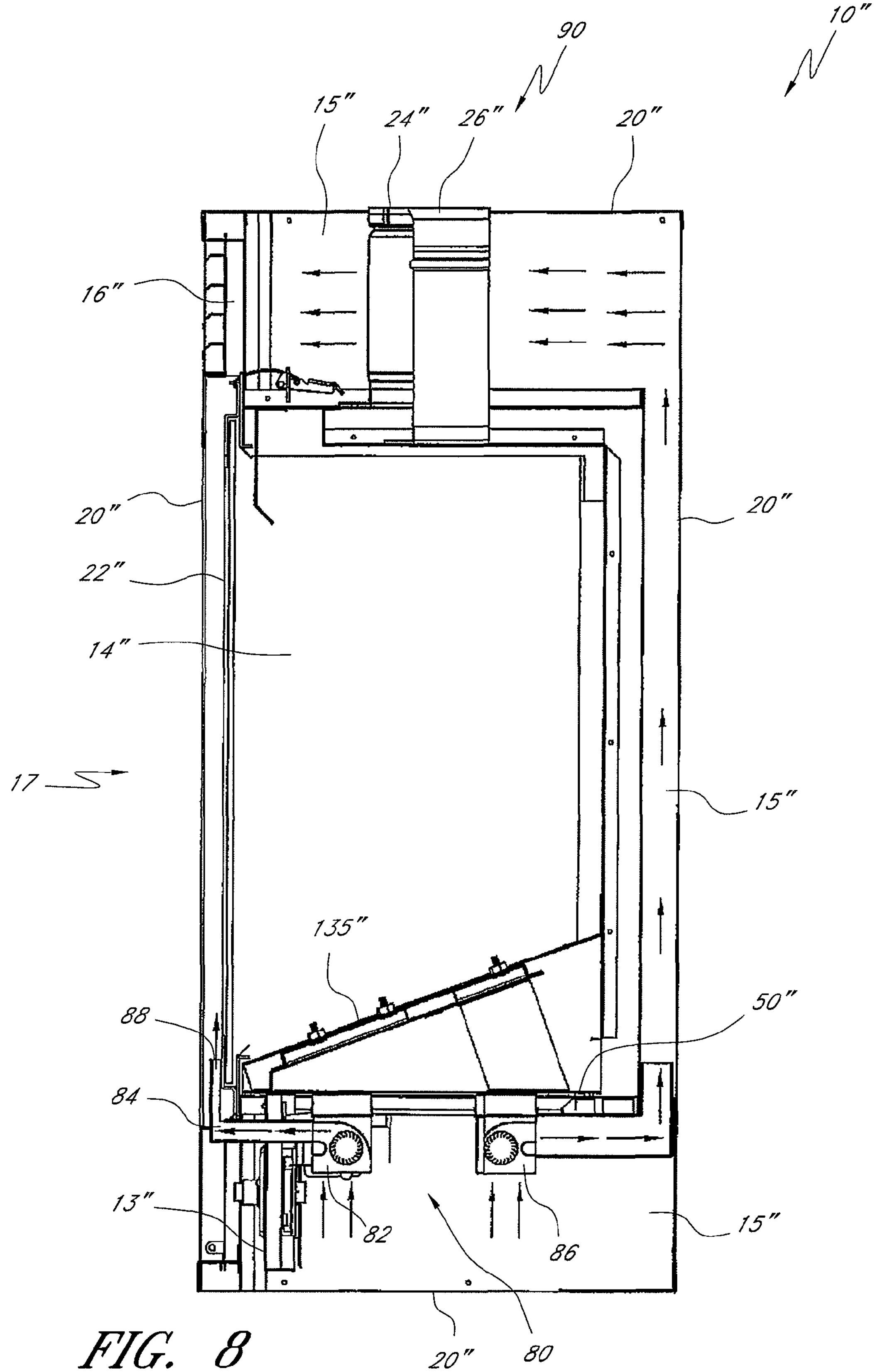


FIG. 8

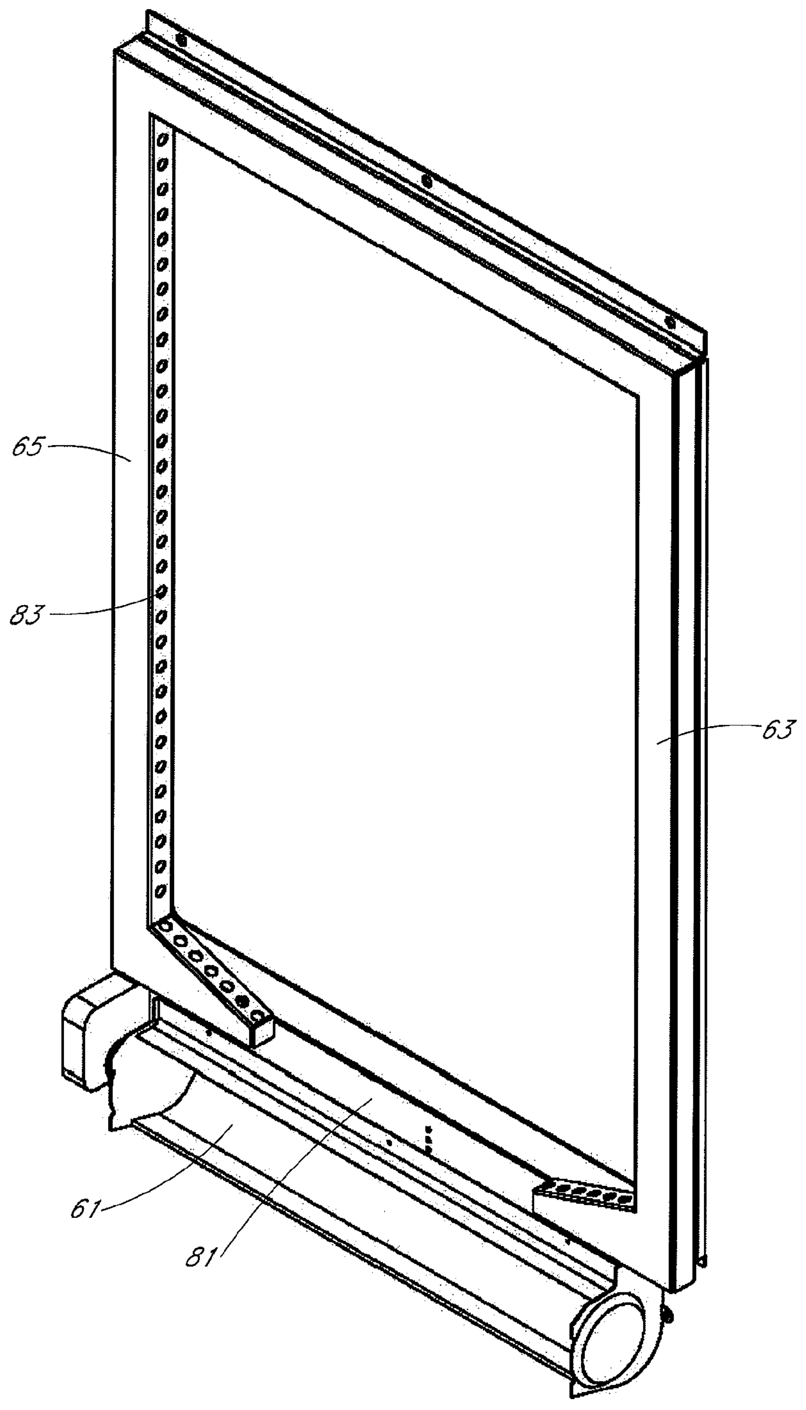


FIG. 9

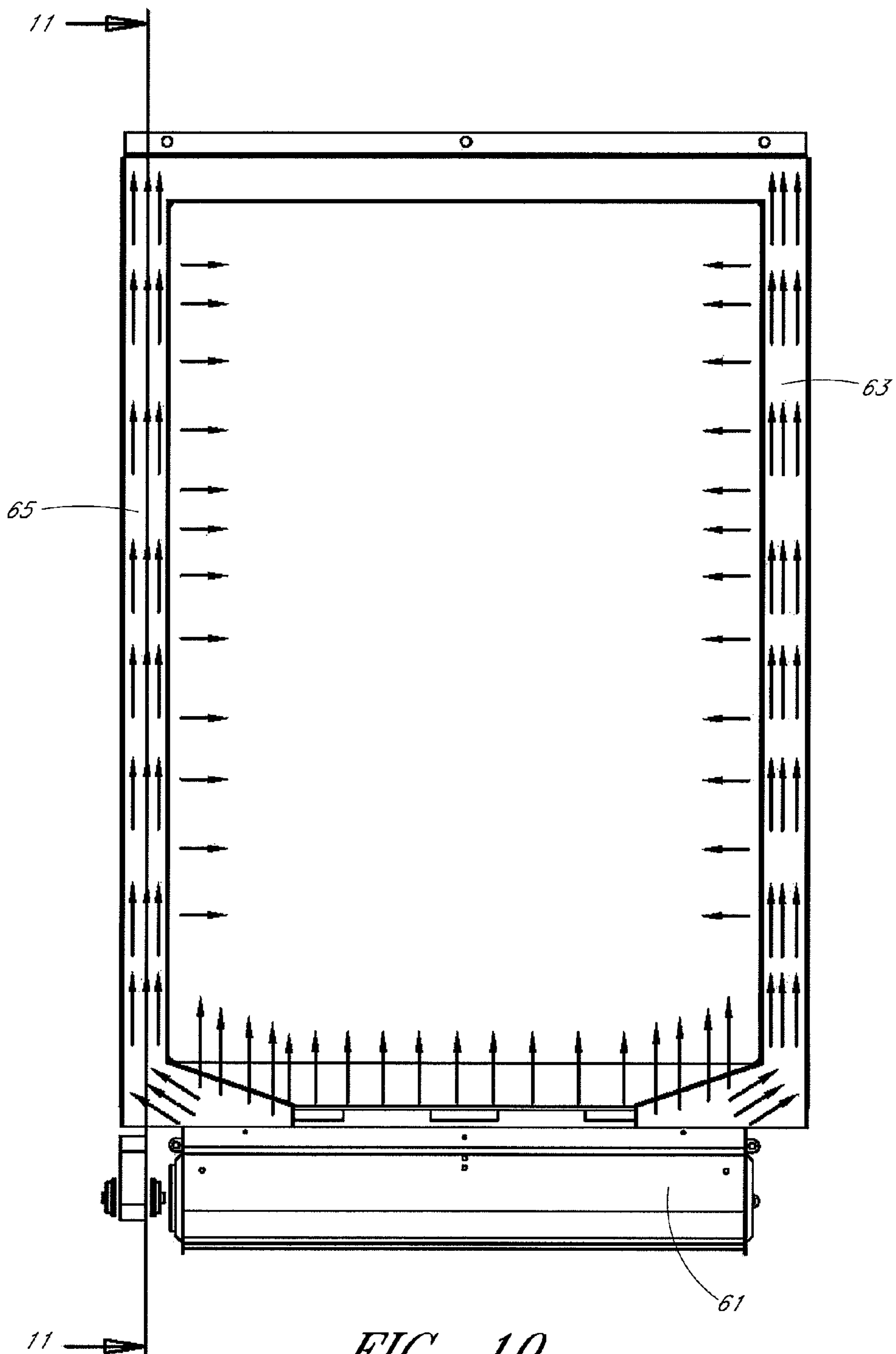


FIG. 10

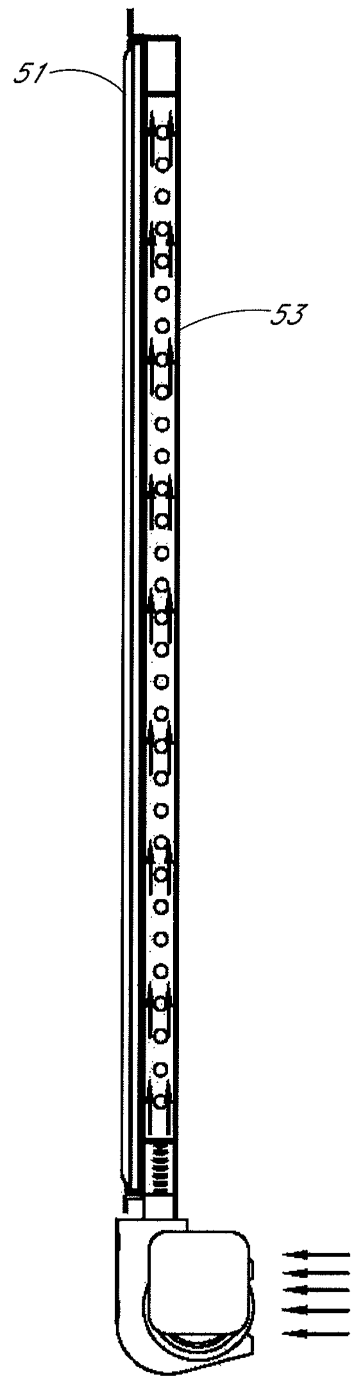
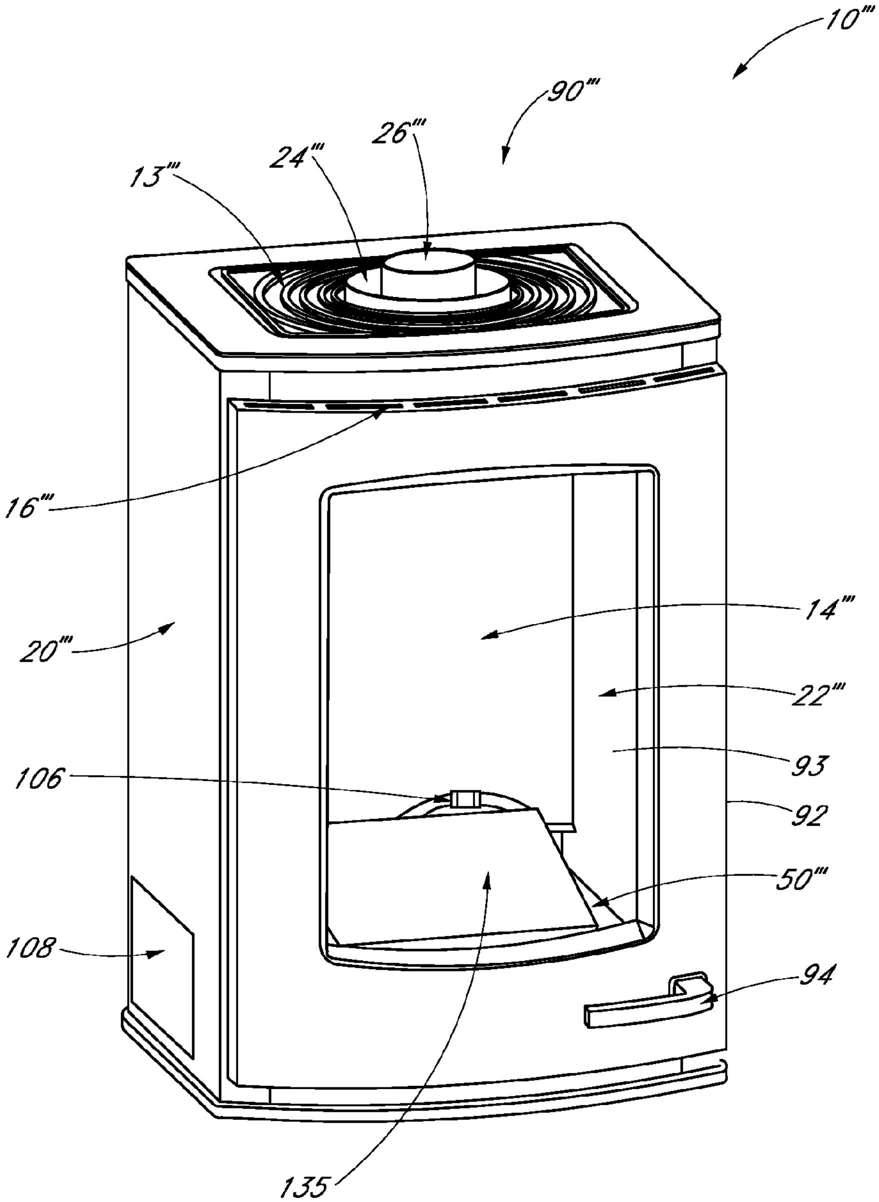


FIG. 11



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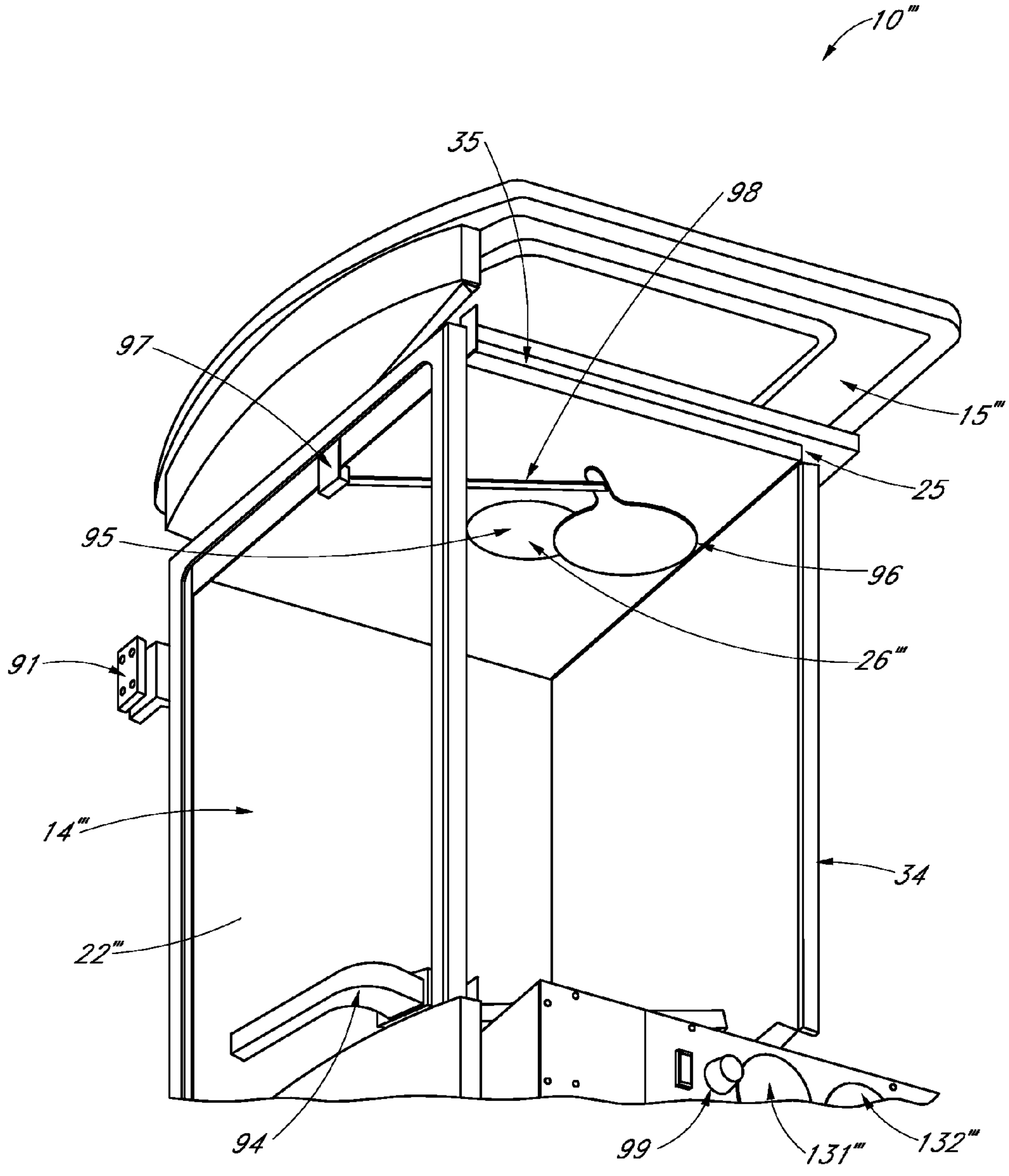
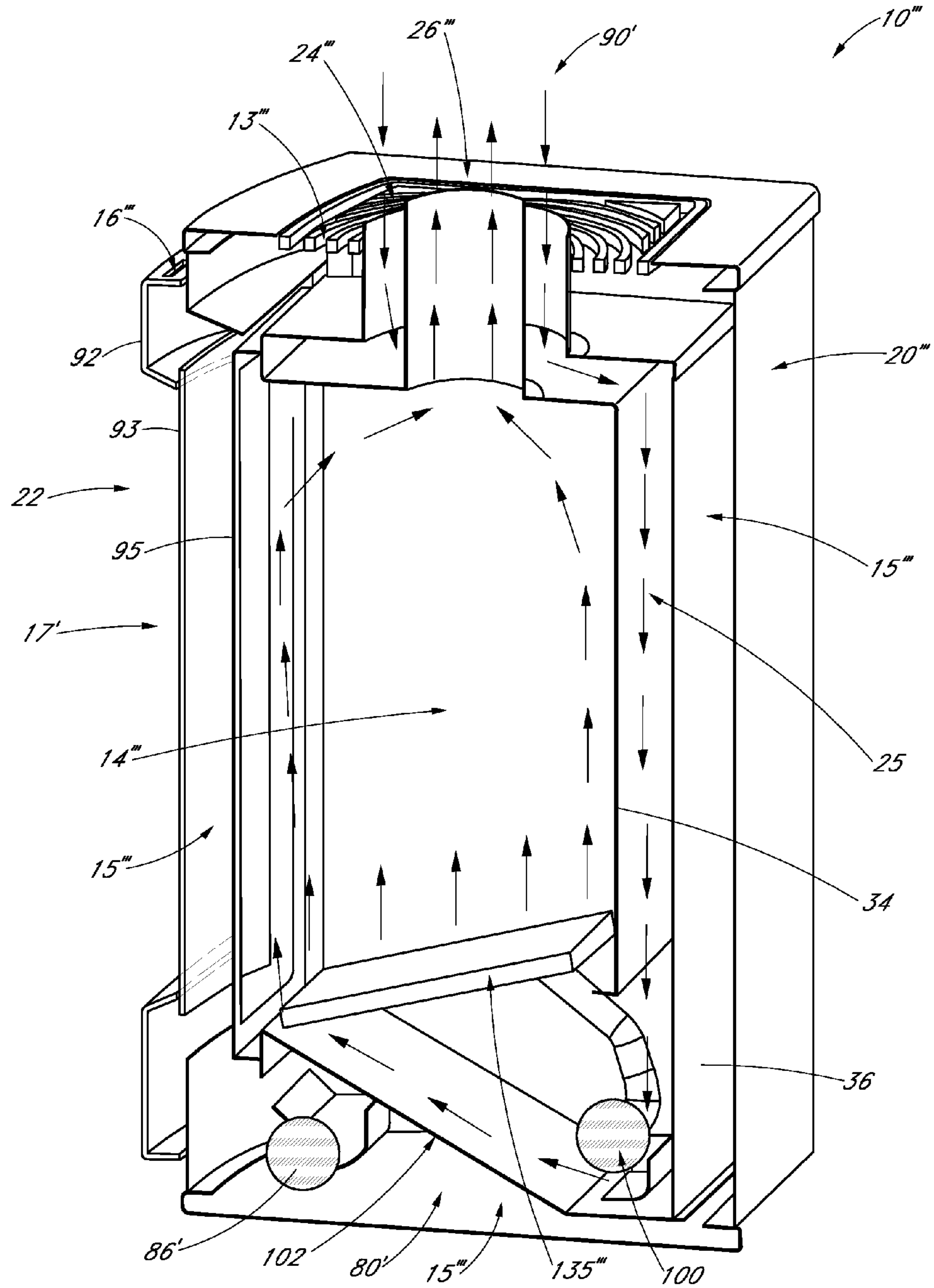


FIG. 13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15''''
135''''
100

FIG. 14

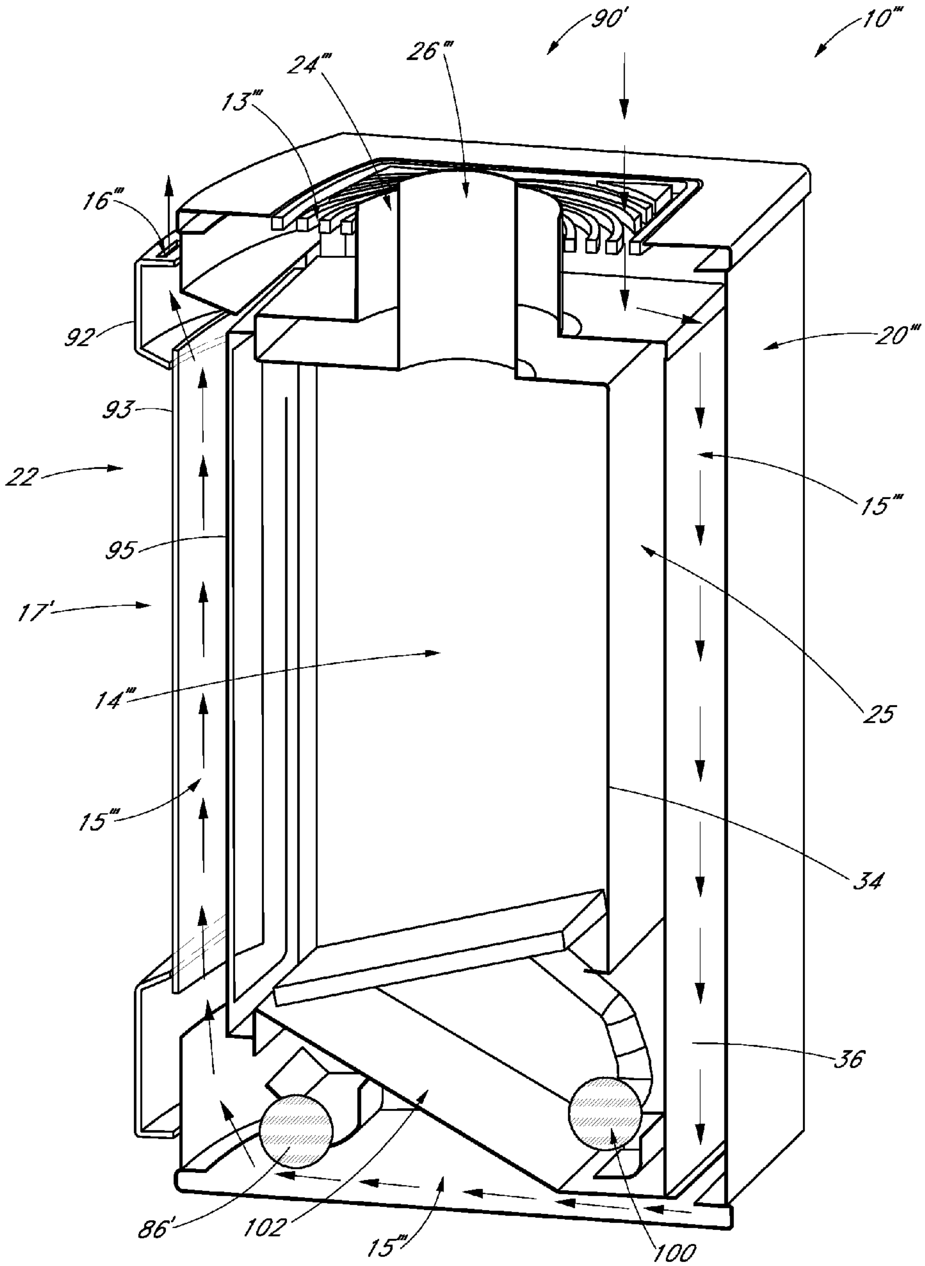

FIG. 15

HEATING APPARATUS WITH FAN

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to and claims priority to Chinese Patent Application No. 201120452598.X, filed on Nov. 17, 2011, and U.S. Provisional Application No. 61/562,846, filed on Nov. 22, 2011, the entire contents of both of which are hereby incorporated by reference herein and made a part of this specification. U.S. Provisional Application Nos. 61/368,637, filed Jul. 28, 2010, and 61/408,549, filed Oct. 29, 2010, are also hereby incorporated by reference herein and made a part of this specification. U.S. Pat. No. 7,434,447, filed on May 30, 2006, and U.S. patent application Ser. No. 12/797,511, filed on Jun. 9, 2010, are also hereby incorporated by reference herein and made a part of this specification.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Certain embodiments disclosed herein relate generally to heating devices, and relate more specifically to fluid-fueled heating devices, such as, for example, gas heaters, fireplaces, stoves, and other heating devices.

2. Description of the Related Art

Many varieties of heaters, fireplaces, stoves, and other heating devices utilize pressurized, combustible fluid fuels to generate a desired heat output. Some such devices operate with liquid propane gas, while others operate with natural gas. These heating devices achieve high internal temperatures. However, such devices and certain components thereof have various limitations and disadvantages.

SUMMARY OF THE INVENTION

According to some embodiments, a heating apparatus can comprise a sealed combustion chamber and a burner disposed within the sealed combustion chamber. The gas fireplace assembly can also comprise a fuel channel for directing fuel from a fuel source external the sealed combustion chamber to the burner, and an air shutter within the sealed combustion chamber that comprises a rotatable sleeve configured to rotate about a shutter axis and adjust the size of a shutter opening. The heating apparatus can also comprise an air shutter control comprising a shaft, the air shutter control mated with the air shutter such that rotating the shaft rotates the rotatable sleeve.

According to some embodiments, a heating apparatus can comprise a sealed combustion chamber and a burner disposed within the combustion chamber. The combustion chamber can have a front face viewable to a user when the fireplace is in use. The heating apparatus can also comprise a combustion air inlet in fluid communication with the sealed combustion chamber to provide air to the burner and an exhaust air outlet in fluid communication with the sealed combustion chamber to remove exhaust air from the combustion chamber. An outer housing can surround at least a portion of the sealed combustion chamber. A system of channels can comprise at least two of a top channel above the front face, a left side channel to the left of the front face, a right side channel to the right of the front face, and a bottom channel below the front face. The at least two channels can be configured to direct air to the front face of the sealed combustion chamber, and at least one fan can be positioned within the outer housing and configured to direct air into the system of channels.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to better understand the embodiments of the disclosure and to see how it may be carried out in practice, some preferred embodiments are next described, by way of non-limiting examples only, with reference to the accompanying drawings, in which like reference characters denote corresponding features consistently throughout similar embodiments in the attached drawings.

FIG. **1** is a schematic view of a heating device.

FIG. **2** is a perspective view of an embodiment of a heating device.

FIG. **2**A is a perspective view of an embodiment of a fuel delivery system compatible with the heating device of FIG. **2**.

FIG. **3** is a perspective view of another embodiment of a heating device.

FIG. **3**A is a partially disassembled perspective view of the heating device of FIG. **3**.

FIG. **3**B is a perspective view of an embodiment of a fuel delivery system compatible with the heating device of FIG. **3**.

FIGS. **4**A-D show front, side, back and top views of an embodiment of an air shutter control.

FIG. **4**E shows an exploded view of the air shutter control of FIGS. **4**A-D.

FIG. **5** shows the air shutter control of FIGS. **4**A-D attached to an air shutter.

FIG. **6** shows an embodiment of an air shutter control.

FIG. **7** is a perspective view of another embodiment of a heating device.

FIG. **8** is a partially disassembled cross-section side view of the heating device of FIG. **7**.

FIG. **9** is a perspective view of a cooling structure.

FIG. **10** is a front view of the cooling structure of FIG. **9**.

FIG. **11** is a cross-sectional side view of the cooling structure of FIG. **9**.

FIG. **12** is a perspective view of another embodiment of a heating device.

FIG. **13** is a partially disassembled cross-section perspective view of the heating device of FIG. **12**.

FIG. **14** is a partially disassembled cross-section perspective view of the heating device of FIG. **12**.

FIG. **15** is partially disassembled cross-section perspective view of the heating device of FIG. **12**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Many varieties of space heaters, wall heaters, stoves, fireplaces, fireplace inserts, gas logs, and other heat-producing devices employ combustible fluid fuels, such as liquid propane and natural gas. The term "fluid," as used herein, is a broad term used in its ordinary sense, and includes materials or substances capable of fluid flow, such as, for example, one or more gases, one or more liquids, or any combination thereof. Fluid-fueled units, such as those listed above, generally are designed to operate with a single fluid fuel type at a specific pressure or within a range of pressures. For example, some fluid-fueled heaters that are configured to be installed on a wall or a floor operate with natural gas at a pressure in a range from about 3 inches of water column to about 6 inches of water column, while others are configured to operate with liquid propane at a pressure in a range from about 8 inches of water column to about 12 inches of water column. Similarly, some gas fireplaces and gas logs are configured to operate with natural gas at a first pressure, while others are configured to operate with liquid propane at a second pressure that is different from the first pressure. As used herein, the terms "first" and "second" are used for convenience, and do not connote a hierarchical relationship among the items so identified, unless otherwise indicated.

Direct vent fireplaces provide efficient heating and do not require a chimney for operation. A direct vent fireplace can direct external ambient air through a combustion vent system for heat generating combustion, and thus does not deprive interior living spaces of oxygen or heated air. Direct vent fireplaces use a balanced flow of combustion air and exhaust gas moving through the combustion fluid intake and exhaust ducts to provide an aesthetically desirable flame in the firebox. Desirable flame characteristics can include, for example, appearing similar to a natural wood-fire flame. The size, color and action of the flames in the firebox can be adjusted by selectively balancing the flow of combustion air and exhaust gas. A balanced flow also allows direct vent fireplaces to function in a thermally efficient manner. Accordingly, an important part of the fireplace insert's installation is to properly balance the combustion air intake flow and the exhaust gas flow. A direct vent fireplace can also provide heat via radiant energy transmitted through the glass enclosure of the fireplace front face. In addition, the combustion chamber enclosure structure reaches elevated temperatures during fireplace operation, e.g. the firebox, glass window, or the like. The combustion chamber of a direct vent fireplace is desirably "sealed." As will be appreciated by those of skill in the art, as used herein a "sealed combustion chamber" is sealed to the extent that it effectively seals the space desired to be heated (usually an interior room) from (1) air from an external source (usually ambient air from outdoors to be used in the combustion process and (2) exhaust created from the combustion process.

In addition, in some instances, the appearance of a flame produced by some fluid-fueled units is important to the marketability of the units. For example, some gas fireplaces and gas fireplace inserts are desirable as either replacements for or additions to natural wood-burning fireplaces. Such replacement units can desirably exhibit enhanced efficiency, improved safety, and/or reduced mess. In many instances, a flame produced by such a gas unit desirably resembles that produced by burning wood, and thus preferably has a substantially yellow hue.

The amount of oxygen present in the fuel at a combustion site of a unit (e.g., at a burner) can affect the color of the flame produced by the unit. Accordingly, in some units, one or more components of the unit are adjusted to regulate the amount of air that is mixed with the fuel to create a proper air/fuel mixture at the burner. Such adjustments can be influenced by the pressure at which the fuel is dispensed.

The conventional insert-style fireplace insert is typically installed and balanced by first sliding the insert into a close-fit fireplace cavity so a limited access space is provided between the fireplace insert and the cavity's walls. The installer reaches through the limited access space to connect the fireplace insert to the exhaust duct and the intake duct. The installer then balances the flow of combustion air and the exhaust gas while the fire is burning in the firebox in order to visually analyze the flame characteristics. Limited access to the adjustment mechanisms for the intake duct, the exhaust duct or an air shutter can make this balancing a time-consuming and labor intensive process requiring multiple adjustments of the adjustment mechanisms during installation.

Some fluid-fueled fireplace units generate hot surfaces about the various features of the fireplace. For example, fireplaces having a sealed, or semi-sealed, or partially sealed window or viewing space on the front face of the unit can reach unsafe temperatures due to the risk of burning the skin, or igniting other objects in close proximity to or touching such a surface. In addition, thermal cycling experienced by the viewing space structure, or glass window, subjects the glass to increased loads that can reduce the durability of the structure. The proximity of the glass portion of a front face to the intense heat emitted by the fireplace burner increases these types of concerns and the maintenance costs of the gas fireplace.

Certain embodiments disclosed herein reduce or eliminate one or more of the foregoing problems associated with existing fluid-fueled devices and/or provide some or all of the desirable features detailed herein. Although certain embodiments discussed herein are described in the context of directly vented heating units, such as fireplaces and fireplace inserts, it should be understood that certain features, principles, and/or advantages described are applicable in a much wider variety of contexts, including, for example, vent-free heating units, gas logs, heaters, heating stoves, cooking stoves, barbecue grills, water heaters, and any flame-producing and/or heat-producing fluid-fueled unit or appliance, including without limitation units that include a burner of any suitable variety.

Direct Vent Fireplace

For clarity and convenience, a direct vent fireplace without the cooling structure discussed above will first be described with reference to FIGS. **1-5**. It will be understood that one or more of the features of the fireplaces of FIGS. **1-2**A and **3-5** could be used in other embodiments of the fireplaces discussed herein, such as the fireplaces of FIGS. **7-8** and FIGS. **12-15**. FIGS. **1** and **2** illustrate an embodiment of a fireplace, fireplace insert, heat-generating unit, or heating device **10** configured to operate with a source of combustible fuel. In various embodiments, the heating device **10** is configured to be installed within a suitable cavity, such as the firebox of a fireplace or a dedicated outer casing. The heating device **10** can extend through a wall **12**, in some embodiments.

The heating device **10** includes a housing **20**. The housing **20** can include metal or some other suitable material for providing structure to the heating device **10** without melting or otherwise deforming in a heated environment. The housing **20** can define a window **22**. In some embodiments, the window **22** comprises a sheet of substantially clear material, such as tempered glass, that is substantially impervious to heated air but substantially transmissive to radiant energy.

The heating device **10** can include a sealed chamber **14**. The sealed chamber **14** can be sealed to the outside with the exception of the air intake **24** and the exhaust **26**. Heated air does not flow from the sealed chamber to the surroundings; instead air, for example from in an interior room, can enter an inlet vent **13** into the housing **20**. The air can pass through the housing in a conduit, or channel **15**, passing over the outside of the sealed chamber **14** and over the exhaust **26**. Heat can be transferred to the air which can then pass into the interior room through outlet vent **16**.

In some embodiments, the heating device **10** includes a grill, rack, or grate **28**, as in FIG. **2**. The grate **28** can provide a surface against which artificial logs may rest, and can resemble similar structures used in wood-burning fireplaces.

In certain embodiments, the housing **20** defines one or more mounting flanges **30** used to secure the heating device **10** to a floor and/or one or more walls. The mounting flanges **30** can include apertures **32** through which mounting hardware can be advanced. Accordingly, in some embodiments, the housing **20** can be installed in a relatively fixed fashion within a building or other structure.

As shown, the heating device **10** includes a fuel delivery system **40**, which can have portions for accepting fuel from a fuel source, for directing flow of fuel within the heating device **10**, and for combusting fuel. In the embodiment illustrated in FIG. **2**, portions of an embodiment of the fuel delivery system **40** that would be obscured by the heating device **10** are shown in phantom. Specifically, the illustrated heating device **10** includes a floor **50** which forms the bottom of the sealed combustion chamber **14** and the components shown in phantom are positioned beneath the floor **50**.

With reference to FIG. **2**A, an example of a fuel delivery system is shown. The fuel delivery system **40** can include a regulator **120**. The regulator **120** can be configured to selectively receive a fluid fuel (e.g., propane or natural gas) from a source at a certain pressure. In certain embodiments, the regulator **120** includes an input port **121** for receiving the fuel. The regulator **120** can define an output port **123** through which fuel exits the regulator **120**. Accordingly, in many embodiments, the regulator **120** is configured to operate in a state in which fuel is received via the input port **121** and delivered to the output port **123**. In certain embodiments, the regulator **120** is configured to regulate fuel entering the port **121** such that fuel exiting the output port **123** is at a relatively steady pressure. The regulator **120** can function in ways similar to the pressure regulators disclosed in U.S. Pat. No. 7,434,447, filed on May 30, 2006, and U.S. patent application Ser. No. 12/797,511, filed on Jun. 9, 2010, incorporated by reference herein.

The output port **123** of the regulator **120** can be coupled with a source line or channel **125**. The source line **125**, and any other fluid line described herein, can comprise piping, tubing, conduit, or any other suitable structure adapted to direct or channel fuel along a flow path. In some embodiments, the source line **125** is coupled with the output port **123** at one end and is coupled with a control valve **130** at another end. The source line **125** can thus provide fluid communication between the regulator **120** and the control valve **130**.

The control valve **130** can be configured to regulate the amount of fuel delivered to portions of the fuel delivery system **40**. Various configurations of the control valve **130** are possible, including those known in the art as well as those yet to be devised. In some embodiments, the control valve **130** includes a millivolt valve. The control valve **130** can comprise a first knob or dial **131** and a second dial **132**. In some embodiments, the first dial **131** can be rotated to adjust the amount of fuel delivered to a burner **135**, and the second dial **132** can be rotated to adjust a setting of a thermostat. In other embodiments, the control valve **130** comprises a single dial **131**.

In many embodiments, the control valve **130** is coupled with a burner transport line or channel **137** and a pilot transport or delivery line **141**. The burner transport line **137** can be coupled with a nozzle assembly **140** which can be further coupled with a burner delivery line **143**. The nozzle assembly **140** can be configured to direct fuel received from the burner transport line **132** to the burner delivery line or channel **143**.

The pilot delivery line **141** is coupled with a safety pilot, pilot assembly, or pilot **180**. Fuel delivered to the pilot **180** can be combusted to form a pilot flame, which can serve to ignite fuel delivered to the burner **135** and/or serve as a safety control feedback mechanism that can cause the control valve **130** to shut off delivery of fuel to the fuel delivery system **40**. Additionally, in some embodiments, the pilot **180** is configured to provide power to the control valve **130**. Accordingly, in some embodiments, the pilot **180** is coupled with the control valve **130** by one or more of a feedback line **182** and a power line **183**.

The pilot **180** can comprise an igniter or an electrode configured to ignite fuel delivered to the pilot **180** via the pilot delivery line **141**. Accordingly, the pilot **180** can be coupled with an igniter line **184**, which can be connected to an igniter actuator, button, or switch **186**. In some embodiments, the igniter switch **186** is mounted to the control valve **130**. In other embodiments, the igniter switch **186** is mounted to the housing **20** of the heating device **10**. The pilot **180** can also comprise a thermocouple. Any of the lines **182**, **183**, **184** can comprise any suitable medium for communicating an electrical quantity, such as a voltage or an electrical current. For example, in some embodiments, one or more of the lines **182**, **183**, **184** comprise a metal wire.

The burner delivery line **143** is situated to receive fuel from the nozzle assembly **140**, and can be connected to the burner **135**. The burner **135** can comprise any suitable burner, such as, for example, a ceramic tile burner or a blue flame burner, and is preferably configured to continuously combust fuel delivered via the burner delivery line **143**.

The flow of fuel through the fuel delivery system **40**, as shown, will now be described. A fuel is introduced into the fuel delivery system **40** through the regulator **120** which then proceeds from the regulator **120** through the source line or channel **125** to the control valve **130**. The control valve **130** can permit a portion of the fuel to flow into the burner transport line or channel **132**, and can permit another portion of the fuel to flow into the pilot transport line or channel **141**. The fuel flow in the burner transport line **132** can proceed to the nozzle assembly **140**. The nozzle assembly **140** can direct fuel from the burner transport line or channel **132** into the burner delivery line or channel **143**. In some embodiments, fuel flows through the pilot delivery line or channel **141** to the pilot **180**, where it is combusted. In some embodiments, fuel flows through the burner delivery line or channel **143** to the burner **135**, where it is combusted.

An air shutter **150** can also be along the burner delivery line **143**. The air shutter **150** can be used to introduce air into the flow of fuel prior to combustion at the burner **135**. This can create a mixing chamber **157** where air and fuel is mixed together prior to passing through the burner delivery line **143** to the burner **135**. The amount of air that is needed to be introduced can depend on the type of fuel used. For example, propane gas at typical pressures needs more air than natural gas to produce a flame of the same size.

The air shutter **150** can be adjusted by increasing or decreasing the size of a window **155**. The window **155** can be configured to allow air to pass into and mix with fuel in the burner delivery line **143**.

The air shutter **150**, along with the burner **135** and the pilot **180** can be within the sealed combustion chamber **14**. Because the combustion chamber **14** is sealed, it can be difficult to access components within the combustion chamber **14**. For this reason some of the components are within the combustion chamber **14** but many are not. In some embodiments, only the components necessary for combustion are within the chamber **90** and all others are outside the chamber **14**. For example, the other components can be in the channel **15** of the housing **20** (FIG. **1**). It is necessary for connecting pipes, lines or channels and some parts of other components to pass into the sealed combustion chamber **14** and remain partially inside the sealed combustion chamber **14** and partially outside. Fittings can be used to allow the necessary components to pass into the chamber **14** while otherwise sealing the entry point into the sealed combustion chamber **14**.

As the air shutter **150** is within the sealed combustion chamber **14**, it can be difficult to adjust to the proper setting. In some currently available heaters, a long screw is used to adjust the air shutter. The long screw passes into the sealed combustion chamber through a fitting and the end attaches to the air shutter. Advancing or withdrawing the screw into or out of the sealed combustion chamber can move the air shutter to adjust the size of the window. A long screw can be cumbersome and does not provide any indication to the user as to the position of the air shutter.

FIGS. **3**, **3**A and **3**B illustrate another embodiment of a heating device **10'** and a fuel delivery system **40'** compatible with the heating device **10'**. Numerical reference to components is the same as previously described, except that a prime symbol (') has been added to the reference. Where such references occur, it is to be understood that the components are the same or substantially similar to previously-described components.

As can be seen in FIG. **3**, a direct vent heating device **10'** can have a housing **20'** which encloses a sealed chamber **14'** with a burner **135'** inside the sealed chamber. FIG. **3**A shows the heating device **10'** in a partially disassembled view. For example, part of the outer housing **20'**, such as vents **13'**, **16'** have been removed, as has the floor **50'**. This view shows some of the components of the heating device **10'**, such as parts of the fuel delivery system **40'**.

Turning now to FIG. **3**B an embodiment of a fuel delivery system **40'** is shown that can be compatible with many different heating devices including the heating device shown in FIG. **3**. The fuel delivery system **40'** can include many of the components previously described with respect to FIG. **2**A, such as a pilot assembly **180'**, an igniter **186'** and a control valve **130'**.

Also shown in FIG. **3**B is a basket **52**. The inner portion **54** of the basket **52** can be part of the sealed chamber **14'**. The basket **52** can be used to store certain parts of the heating device such as components of the fuel delivery system **40'** within the sealed chamber **14'**. The basket **52** can also attach to the floor **50'** and can be configured to allow certain components, pipes, wires, etc. to pass through the basket **52**. Gaskets **56** can be used to seal access points into the basket **52**, floor **50'** or other parts of the sealed chamber **14'**.

FIGS. **4**A-E illustrate one embodiment of an improved air shutter control **60**. In some embodiments, the air shutter control **60** can replace the nozzle assembly **140** in FIG. **2**A, similar to the configuration shown in FIG. **3**B. The burner transport line **137'** can connect to an inlet **62** on the air shutter control **60**. Fuel can be directed from the inlet **62** through a valve **64** to an injector orifice or nozzle **66**. The fuel can be injected into the mixing chamber **157'** to mix with air introduced through the air shutter **150'** to pass into the burner delivery line **143'** to then be delivered to the burner **135'** for combustion.

Looking now at FIG. **5**, as shown, an air shutter **150'** can comprise a cylinder or other shape with a slot **80** sized to fit on ledge **68** of the valve **64**. The air shutter **150'** can be configured to move with the valve **64**. In some embodiments, the air shutter **150'** can be fastened on to the valve **64** either at the ledge **68** or otherwise. This can be done, for example, with a friction fit between the slot **80** and the ledge **68**. In some embodiments, the nozzle **66** can also be configured to move with the valve. In some embodiments, the valve **64**, the nozzle **66** and the air shutter **150'** all rotate about the same axis. In some embodiments, the nozzle **66** and the air shutter **150'** are coaxial.

The air shutter **150'** can also have a slot or hole **82**. In some embodiments, the burner delivery line **143'** has a corresponding slot or hole **84**. The overlap between the holes **82** and **84** can create a window **155'** that can allow air to pass into the mixing chamber **157'** to mix with the fuel.

The air shutter control **60** can have a user interface surface **70**. The user interface surface **70** can be used to control the position of the air shutter **150'** and conversely the amount of air that can enter the mixing chamber **157'**. The user interface surface **70** can comprise a knob connected to the valve **64**. In other embodiments, not shown, the user interface surface **70** can comprise other types of mechanical controls such as a lever, a wheel, a switch, or some other device to transfer a user's movement to move the air shutter **150'**. In other embodiments, also not shown, the user interface surface **70** can comprise an electrical or computer control, including but not limited to electrical buttons, electrical switches, a touch screen, etc.

According to some embodiments, the user interface surface **70** can be outside of the sealed combustion chamber **14'** and the air shutter **150'** can be inside of the sealed combustion chamber **14'**. For example, the flange **76** can be used as a fitting to attach the air shutter control **60** to a basket **52** or to a wall of or the floor **50'** of the sealed combustion chamber **14'**. The injector orifice **66** and the part of the valve attached to the air shutter can be inside the sealed combustion chamber **14'** while the rest of the valve, the flange **76** and the user interface surface **70** can be outside of the sealed combustion chamber **14'**.

FIG. **6** illustrates another embodiment of an air shutter **150""**. Numerical reference to components that are the same as previously described use the same number but include a quadruple prime symbol (""). Where such references occur, it is to be understood that the components are the same or substantially similar to previously-described components.

In FIG. **6**, as in some embodiments described above, the air shutter can have a body which defines a slot or hole **82""** that overlaps with a corresponding slot or hole **84""** in the burner delivery line, creating a window **155""** that can allow air to pass into the mixing chamber **157""** to mix with the fuel.

The air shutter can have a gear member **85** with a plurality of shutter teeth **87** on its outer surface. The air shutter can also have an air shutter control **60""** with a user interface surface **70""** that is able to control the air shutter by means of a shaft **73** to which is secured to control teeth **75** that cooperate with the shutter teeth **87**. When a user rotates the user interface surface, the shaft **73** and control teeth **75** rotate, the control teeth applying a force to the shutter teeth **87** which rotates the shutter teeth, the body of the shutter and, thereby, the slot or hole **82""**, increasing or decreasing the size of the window. In some embodiments the control teeth **75** are part of a collar **79** that surrounds the shaft **73**. In other embodiments the control teeth are part of the shaft itself.

In various embodiments the shutter teeth **87** and control teeth **75** have a variety of designs. They can be cut, for example, as spur gears, bevel gears, helical gears, or any other tooth design known in the art. Additionally, various embodiments may have different tooth designs for the shutter teeth **87** and the control teeth **75**. For example, the control teeth may be cut as a worm gear while the shutter teeth may be cut as a spur gear or a helical gear.

The gear ratio between the shutter teeth **87** and control teeth **75** can vary across different embodiments. In some embodiments where spur gears are used, the ratio of shutter teeth to control teeth can be between about 1.5 and about 2. In some embodiments it can be between about 2 and about 3, between about 3 and about 5, between about 4 and about 7, or between about 5 and about 8. In some embodiments the ratio can be greater than 8. In some embodiments, the ratio can be between about 1.5 and about 8, between about 2 and about 8, between about 3 and about 8, between about 4 and about 8, or between about 5 and about 8. In some embodiments, it can be between about 1.5 and about 16, between about 2 and about 16, between about 4 and about 16, between about 6 and about 16, or between about 8 and about 16.

Desirably, but not always, at least 120 degrees of rotation of the user interface surface **70""** (and/or shaft **73**) is required to change the air shutter from a minimum airflow position with the window **155""** fully closed or substantially fully closed, to a maximum airflow position with the window **155""** fully open or substantially fully open. In other embodiments the gear ratio can be configured such that the user interface surface **70""** must rotate at least 150, 180, 210, 240, 270, 300, 330, or 360 degrees in order to change the air shutter from a minimum airflow position to a maximum airflow position. This air shutter adjustment offers the user improved control over the airflow that mixes with the fuel. In embodiments where even more precise control of the airflow is desired, the gear ratio can be set such that more than a 360 degree rotation of the user interface surface **70""** is required to change the air shutter from a minimum airflow position to a maximum airflow position. In various embodiments at least 420, 480, 540, 600, 660, or 720 degrees of rotation may be required.

In some embodiments, it can be preferable for the user interface **70""** and/or the shaft to rotate between about 120 and about 360 degrees to change the air shutter from a minimum airflow position to a maximum airflow position. In some embodiments, the user interface and shaft may rotate between about 120 and about 720 degrees, between about 180 and about 720 degrees, between about 360 and about 720 degrees, or between about 540 and 900 degrees to change the air shutter from a minimum airflow position to a maximum airflow position. In some embodiments, the user interface and shaft may rotate between about 120 and about 180 degrees, between about 180 and about 270 degrees, between about 270 and about 360 degrees, between about 360 and about 450 degrees, between about 450 and about 540 degrees, between about 540 degrees and about 630 degrees, or between about 630 and about 720 degrees to change the air shutter from a minimum airflow position to a maximum airflow position.

In some embodiments the size of the window **155""** formed between the air shutter slot or hole **82""** and the burner delivery line slot or hole **84""** can be adjusted. With reference to FIG. **6**, the size of the window can be defined in terms of an angle θ formed by two lines emanating from the center of a cross-section of the shutter and in the same plane as the cross-section, where one line passes through a first edge of the window **155""** when fully open, and where the second line passes through a second edge of the window **155""** when fully open. For example, a window **155""** that occupies a third of the circumference of the shutter when the window is fully open would have an angle θ of 120 degrees. Various embodiments of the air shutter can have a window that is at least 5, 10, 20, 30, 40, 45, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, or 180 degrees. Various embodiments of the air shutter can have a window that is less than 5, 10, 20, 30, 40, 45, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, or 180 degrees. Varying the rotation required to change the air shutter from a minimum airflow position to a maximum airflow position can be done by adjusting the gear ratio, as described above, by adjusting the size of the window, or by adjusting both the gear ratio and the size of the window.

Additionally, some embodiments can have two separate air shutter controls, an air shutter control with a gear ratio set for coarse control of the air shutter and an air shutter control with a gear ratio set for fine control of the air shutter. The air shutter control set for coarse control can interlock with the shutter teeth at one side of the gear member, and the air shutter control set for fine control can interlock with the shutter teeth at another side of the gear member. Both of the air shutter controls can have different gear ratios with respect to the shutter teeth, such that the coarse air shutter control requires less angular motion than the fine air shutter control to make the same adjustment to the air shutter. Alternatively, an air shutter can have two gear members, one of which interfaces with a coarse air shutter control and another of which interfaces with a fine air shutter control.

The shaft position relative to the axis of rotation of the shutter depends on the design of the shutter teeth **87** and the control teeth **75**. In some embodiments the shaft **73** is substantially perpendicular to the axis of rotation of the shutter **150""**, as illustrated by FIG. **6**. While not a necessary part of the invention, a shaft substantially perpendicular to the axis of rotation of the shutter **150""** offers some advantages. For example, it will typically allow the air shutter control **60""** to be on the same side of the gas fireplace assembly as the dials for the control valve, in contrast to the positioning seen in FIG. **3**B. Having the air shutter control and the dials for the control valve near each other can simplify operation of the gas fireplace assembly.

As discussed with respect to various embodiments above, the air shutter control **60""** can have a user interface surface **70""** that can comprise a knob, other types of mechanical controls, or an electrical or computer control. In embodiments of FIG. **6** with an electrical or computer control, a stepper motor can be used to rotate the shaft **73**, allowing for precision control of the air shutter **150""**. The air shutter control can also be designed to provide some indication of the position of the air shutter.

Additional details of the air shutter **150""** and the air shutter control are disclosed in U.S. patent application Ser. No. 12/797,446, which is hereby incorporated by reference in its entirety.

Direct Vent Fireplace with Cooling Structure

The embodiments described in FIGS. **1**-**5** disclose a gas fireplace assembly with several control system embodiments to control the performance parameters of the gas fireplace. Although the description of the embodiments of FIGS. **7** and **8** provided below do not include specific details of a control system, it is understood that the following direct vent fireplace with cooling structure embodiments can include any of the above described control systems, in whole or in part, and any combination thereof of the various components or features of the control systems described above.

In the illustrated embodiments of FIGS. **7** and **8**, another embodiment of a direct vent gas fireplace assembly, or heating device **10"**, is shown. Numerical reference to components is the same as previously described, except that a double prime symbol (") has been added to the reference. Where such references occur, it is to be understood that the components are the same or substantially similar to previously-described components.

FIG. **7** shows a perspective view of the heating device **10"** in an assembled view, with the exception of the front grill of the inlet vent **13"** having been removed for clarity. The control system and fuel delivery system details are not shown; however, the control system and fuel delivery system can be any of the embodiments or a combination thereof, as described in detail above. FIG. **8** shows the heating device **10"** in a partially disassembled view. For example, part of the control system and fuel delivery system has been removed for clarity.

The heating device **10"** can include a housing **20"** that encloses a sealed combustion chamber **14"** with a burner **135"** inside the sealed combustion chamber. The sealed chamber **14"** can be sealed to the outside with the exception of the air intake **24"** and the exhaust **26"**. Heated air does not flow from the sealed chamber **14"** to the surroundings; instead air, for example from in an interior room, can enter an inlet vent **13"** into the housing **20"**. The heating device **10"** can further include an air circulation system **80** having one or more of a heating channel **15"**, inlet vent **13"**, climate control outlet vent or exhaust **16"**, cooling fan **82**, cooling channel **84**, and climate control fan **86**.

As shown, the air circulation system **80** can be configured to deliver heated air to the interior room, or interior space, where the heating device **10"** is installed, and to deliver cooling air to a front face **17** of the heating device **10"**.

The heating channel, conduit, or passage **15"** can be disposed about, and extend proximate, the external surface of the sealed combustion chamber **14"**. The channel **15"** can include a spaced gap between the sealed combustion chamber **14"** and the fireplace housing **20"**. The channel **15"** can be located on one or more sides of the fireplace assembly. For example, as shown, the channel **15"** can be located on the bottom side, the back side, and the top side of the fireplace assembly. In some embodiments, the channel **15"** can be located on the right side and/or left side of the fireplace assembly. The fluid channel **15"** can be sufficiently proximate to the combustion chamber to heat the fluid, or room air, which is delivered through the channel **15"**. In some embodiments, the channels can share a wall with the housing defining the combustion chamber **14"**.

With continued reference to FIGS. **7** and **8**, the channel **15"** can be configured to receive interior room air, or climate control air, from the climate control air inlet vent **13"**, deliver the climate control air about a proximity of the sealed combustion chamber **14"**, and expel heated climate control air out of the climate control outlet vent **16"**. Heat emitted by the combustion of fuel and combustion air can be transferred to the climate control air delivered through channel **15"** and generate the heated air.

The term "climate control" as used herein, is a broad term used in its ordinary sense, and includes features directed to the distribution of warmed fluid, such as, for example, interior room air, outside ambient air, or the like, and any combination thereof, to influence or control the room temperature where the fireplace is installed. For example, climate control air is distinguished from combustion air; however, in some embodiments, climate control air can provide the source of combustion air to the chamber **14"**, and/or the combustion air source can provide at least a portion of the climate control air.

The climate control fan **86** is configured to deliver, or blow, air through the channel **15"**. The climate control fan **86** can be located adjacent the channel **15"**, or generally positioned anywhere in fluid communication to the channel **15"** flow path. The climate control fan **86** can have a variety of typical fan features, e.g. directed flow vents, variable speed controls, or the like. The climate control fan **86** can be a transflow, or centrifugal, configuration fan. In some embodiments, the climate control fan **86** can be an array of one or more axial propeller fans. In some embodiments, the air flows through the channel **15"** by natural convection, without the assistance of a fan.

The air circulation system **80** can include a second channel, or the cooling channel **84**. The cooling channel **84** can be configured to deliver output air from the cooling fan **82** to front face **17**, i.e. the exterior surface of the window **22"**. In the illustrated embodiment in FIG. **8**, the cooling channel **84** extends under the floor **50"** of the sealed combustion chamber in a forward direction toward the front face **17**, and then extends upward on a lower portion of the front face **17**.

The cooling channel **84** can include a cooling exhaust vent **88** located at the downstream end of the cooling channel. The cooling exhaust vent **88** can be positioned proximate or adjacent to, the window **22"** and front face **17**. The air can cool the exterior surface of the window **22"** to a surface temperature that can be safe to the touch. The cooling channel **84** can deliver a portion of air received by the channel **15"** through the inlet vent **13"**. In some embodiments, the cooling channel can be configured to receive air directly from any air source, e.g. the interior room, outside ambient air, or the like. In addition, the cooling channel **84** and cooling fan **82** can deliver air from a dedicated inlet vent.

As shown, the cooling exhaust vent **88** generally extends, or spans, substantially the full width of the fireplace assembly's front face **17**. In some embodiments, the cooling exhaust vent **88** can span a portion of the front face, e.g. ¼, ½, ¾, substantially the entire width, or the like, across the front face **17**. The vent **88** can be configured to direct air evenly across and over the window **22"** exterior surface via a constant geometry exit area across the vent **88** width. In some embodiments, the cooling exhaust vent **88** can be configured to direct increased proportions of the cooling air flow mass to specific portions of the window. For example, increased cooling air flow can be directed to localized hot spots that have relatively higher surface temperatures, or to portions of the window **22** most likely to incur user contact, such as adjacent a control knob or a door or window handle.

In addition, though FIG. **8** shows the cooling exhaust vent **88** only on the bottom of the window, it is to be understood that the cooling exhaust vent **88** can be located at many different locations along the front face **17**. For example, the cooling exhaust vent **88** can be located along one or more of the sides, the top, and/or the bottom of the front face **17**. In addition, the cooling exhaust vent **88** can include one or more cooling fans **82** and can comprise one or more cooling channels **84** which may or may not be connected.

FIGS. **9-11** illustrate one embodiment of the cooling structure where it comprises multiple cooling channels. In the illustrated embodiment, the cooling structure comprises three connected cooling channels: a bottom channel **61**, a left side channel **63**, and a right side channel **65**. In FIGS. **10** and **11**, the arrows represent the path of airflow through the cooling structure.

In some embodiments, the rear side **53** of the cooling structure can have a window mounted to it, and the air that exits the cooling structure will directly cool the exterior surface of the window, as described above. In other embodiments, the cooling structure can have windows mounted to the rear side **53** and the front side **51** such that the air that exits the cooling structure will enter the space between the windows to thereby cool the front window.

As illustrated in FIG. **10**, some air that exits the bottom channel can exit directly toward the front face, helping cool it, while some air that exits the bottom channel can flow into other channels. In some embodiments, as described above, all of the air that exits the bottom channel can go to immediately cool the front face. In other embodiments, all of the air that exits the bottom channel can enter other channels.

Air can exit the channels to cool the front face through a variety of means. In some channels, the air can exit through one or more larger outlets **81**. In other channels, the air can exit through a plurality of smaller outlets **83** that can be round, ovular, or any other shape. Still other channels such as the bottom channel illustrated in FIGS. **9-11** can be configured such that air exits through multiple types of openings, such as larger **81** or smaller outlets **83**. Additionally or alternatively, channels can be configured such that air exiting the channel to cool the front face can exit at varying angles relative to the length of the channel. For example, the bottom channel illustrated in FIGS. **9-11** is configured such that air exiting through the smaller outlets **83** exits at a different angle than air exiting through the larger outlets **81**.

It is understood that any type or combination of openings that allow air to exit the channels to cool the front face can be used. Similarly, any exit angle or combination of exit angles can be used in the cooling structure. Different sizing and positioning of openings can focus airflow on desired areas, such as areas with relatively high surface temperatures or areas more likely to incur user contact, as discussed above. Additional channels can provide additional locations to position openings. For example, in some embodiments, the cooling structure can be the same as the embodiment illustrated by FIGS. **9-11**, but with openings in the top channel sized and spaced substantially similar to those used in the side channels **63**, **65**.

Returning to FIG. **8**, the cooling fan **82** is configured to blow air through the cooling channel **84**. In embodiments where there are multiple cooling channels **84**, as illustrated in FIGS. **9-11**, the cooling fan **82** can blow air into one or more of the cooling channels. The following disclosure regarding the cooling fan **82** is understood to apply equally to embodiments with multiple cooling channels as it does to embodiments with a single cooling channel. Descriptions of the cooling channel **84** refer to one, some, or all of the cooling channels.

The cooling fan **82** can be located adjacent the cooling channel **84** and the channel **15"**, or generally positioned anywhere in fluid communication to the cooling channel **84** and the channel **15"** flow path. As mentioned previously, the cooling channel **84** and cooling fan **82** can deliver air from a dedicated inlet vent which may or may not be connected to the channel **15"**. The cooling fan **82** can have a variety of typical fan features, e.g. directed flow vents, variable speed controls, or the like. The cooling fan **82** can be a transflow, or centrifugal, configuration fan. In some embodiments, the cooling fan **82** can be an array of one or more axial propeller fans.

The cooling fan **82** can generally span a sufficient width of the cooling channel **84** to provide a consistent and even flow of cooling air across a substantial portion of the window **22"**. In some embodiments, the cooling fan **82** can span ¼, ½, ¾, the entire width, or any other sufficient portion of the cooling channel **84** width, or the window **22"** width, that is sufficient to deliver cooling air over the window **22"**. The cooling fan **82** can be sized to provide sufficient capacity, or air mass flow rate capability, to cool the exterior surface of the window **22"** to safe temperatures. The cooling airflow exiting the vent **88** can generally flow up substantially the full height off the window **22"**. In some embodiments, the cooling air can flow over a portion of the window **22"** height, e.g. ¼, ½, ¾, substantially the entire height, or the like, up the window **22"**. The cooling fan **82** can be positioned under the sealed combustion chamber **14"** and generally upstream of the climate control fan **86**; thus, the cooling fan can be located between the inlet vent **13"** and the climate control fan **86**. In some embodiments, the climate control fan **86** can be located upstream of the cooling fan **82**.

The cooling fan **82** can generally be positioned in a first half of the channel **15"** extending from the air inlet vent **13"**. As described above, the channel **15"** can define a flow path from the front face **17** under the floor **50"**, up the back side of the chamber **14"**, and over the top side of the chamber **14"** to the outlet vent **16"**. In some embodiments, the cooling fan **82** can be positioned in a first ¼, ⅓, ⅔, or any portion thereof, of the channel **15"** flow path. Similarly, the cooling fan **82** can be positioned in any portion of the channel **15"** such that the air drawn into and blown out of the fan **82** is not substantially heated by the combustion in the sealed combustion chamber **14"**. In some embodiments, heated air can be drawn into the cooling fan **82** and directed to the window **22"**. In some embodiments, the cooling fan **82** can be located outside of the channel **15"**.

The cooling fan **82** can include a control module, which is not shown, that is coupled to, and can control, the operation of the fan **82** and the burner **135"**. The control module can cool the window **22"** by activating the fan **82** when the burner **135"** is in operation, or activated. The control module can further deactivate, or turn off, the burner **135"** when the control module receives input, or a lack thereof, that the cooling fan **82** is not functioning properly. In this manner, the burner **135"** turns off and prevents the window **22"** from becoming excessively hot.

In some embodiments, the control module controls the cooling fan **82** to remain on and blowing cooling air to the window **22"** after the burner **135"** is deactivated. In some embodiments, the cooling fan **82** is controlled to remain on for a predetermined amount of time after the burner **135"** is turned off. The cooling fan can remain on for two, five, ten, or any number of minutes to maintain a cool window temperature. The extended cooling fan operation prevents excessive window temperatures that can result from the transfer of residual heat in the walls, or structure, of the sealed combustion chamber, or firebox. The predetermined time can be factory set, or can be adjusted by the user during or after installation. In some embodiments, the predetermined time can be adjusted via a control module interface, which is not shown.

In some embodiments, the fireplace assembly can include a thermocouple proximate the window **22"**, or more preferably an exterior surface of window **22"**. The thermocouple can provide a feedback control system with the control module that can keep the cooling fan **82** activated until the window achieves a predetermined safe temperature. The predetermined temperature can be factory set or selected by the user after installation.

The direct vent heating device **10"** can provide efficient heating and does not require a chimney for safe operation.

The direct vent heating device **10"** can direct outside ambient air through a combustion vent system **90** for heat generating combustion, and thus does not deprive interior living spaces of oxygen or heated air.

The heating device **10"** can include a combustion vent system **90**, or flue, that can extend outward from the heating device **10"** and be directed horizontally through an external wall or vertically to a roof. As shown, the vent system **90** includes two collinear ducts, the inner and outer flue, or the combustion air intake duct **24"** and the combustion air exhaust duct **26"**. The illustrated air exhaust **26"** is smaller in diameter than air intake **24"**, and air exhaust **26"** extends within the larger air intake **24"** and generally shares a common longitudinal axis. The internal air exhaust **26"** generally directs combustion exhaust gas out of the fireplace. The external air intake **24"** generally draws external, or outside, air into the fireplace through the annular space between the smaller diameter combustion exhaust **26"** and the larger diameter air intake **24"**. External air is generally the ambient air outside of the building structure being heated. In some embodiments, the air intake **24"** can be the smaller diameter and extend within the larger diameter air exhaust **26"**. The collinear vent system can improve the system efficiency of heating device **10"** because the air entering in the annular space is warmed by passing over and about the heated combustion exhaust **26"** prior to combustion at the burner **135"**.

Dual Direct Vent and Vent Free Fireplace

The embodiments described in FIGS. **1-8** disclose a gas fireplace assembly with several control system embodiments to control the performance parameters of the gas fireplace and a cooling structure for a face of the fireplace. Although the description of the embodiments of FIGS. **12-15** provided below does not include specific details of a control system, it is understood that the following duel direct vent and vent-free fireplace embodiments can include any of the above described control systems, in whole or in part, and any combination of the various components or features of the control systems described above.

In the illustrated embodiments of FIGS. **12-15**, another embodiment of a heating device **10'''**, a dual-function direct vent and vent free gas fireplace assembly, is shown. The heating device **10'''** is able to function in either a direct vent configuration or a vent free configuration. A direct vent fireplace, as described above, can be vented out through the wall or through the roof to the exterior of a structure, building, or home. A vent free gas fireplace does not require an external vent or a chimney, rather the exhaust is vented directly into the interior of a structure, building, or home. The heating device **10'''** can include many similar characteristics and/or features as the heating device **10"** of FIGS. **7** and **8**. Numerical reference to components is the same as previously described, except that a triple prime symbol (''') has been added to the reference. Where such references occur, it is to be understood that the components are the same or substantially similar to previously-described components.

With reference to FIG. **12**, the dual-function direct vent and vent free gas fireplace **10'''** is shown in an assembled view. The control system and fuel delivery system details are not shown; however, the control system and fuel delivery system can be any of the embodiments or a combination thereof, as described in detail above or as further described below. FIG. **13** shows the heating device **10'''** in a partially disassembled cross-section view. For example, parts of the control system and the fuel delivery system have been removed for clarity.

With reference to FIGS. **12** and **13**, the heating device **10'''** desirably can function as both a direct vent fireplace system or as a vent free fireplace system. The dual system fireplace desirably can provide suitable heat in a variety of scenarios, improving the operability of the fireplace in general, e.g. operable both with and without a source of electricity. The fireplace **10'''** can advantageously include at least two features that can accommodate the interchangeable direct vent and vent free configurations within the single fireplace. These features can include a closing mechanism for a combustion chamber exhaust outlet **95** and a removably installed sealed door **92** and/or window **22'''**.

The fireplace **10'''** can include an exhaust pipe **26'''** that can maintain fluid communication between the sealed combustion chamber **14'''** and the ambient environment for expelling the combustion exhaust from the burner **135'''** disposed in the sealed combustion chamber. As has been explained herein, the exhaust pipe **26'''** is used in the direct vent configuration. The combustion chamber outlet **95** at the exhaust pipe **26'''** can include an exhaust cover, or baffle **96**, that can be positioned over the combustion chamber exhaust outlet **95** to seal the combustion chamber **14'''** from the ambient environment. This can allow the heating device **10'''** to be used in the vent free configuration.

The exhaust cover **96** can fit over the exhaust outlet **95** and prevent heated air from exiting the chamber **14'''** and colder external ambient air from entering the chamber. The cover **96** can have a sealing member, or gasket, non-metallic interface, or the like, to facilitate the sealing feature of the cover. The sealing member can be capable of exposure to the high temperatures of the chamber **14'''**.

It should be noted that the exhaust cover **96** as shown, does not cover the air intake **24'''**. In some embodiments, the fireplace **10'''** can continue to draw, via a pressure differential between the air intake and the combustion at the burner, or the like, external ambient air to combust at the burner **135'''**. In some embodiments, the air intake **24'''** can similarly be closed when using the heating device **10'''** in the vent free configuration. As will be described in more detail below, for vent free operation the window **22'''** can be opened or removed to allow for proper exhaust and/or air inflow. As will be understood, opening or removing the door **92** and/or window **22'''** unseals the previously sealed combustion chamber **14'''** and allows for the exchange of air and exhaust between the combustion chamber and its surroundings.

With particular reference to FIG. **13**, the cover **96** can be pivotably coupled to a controller, or arm member **98**, that desirably can selectively open or close the exhaust outlet **95**. The controller **98** can position the cover **96** over the exhaust pipe **26'''** to completely close the exhaust, or can position the cover adjacent the exhaust **26'''** to completely open the exhaust. In addition, the controller **98** can position the cover **96** anywhere between these two positions. Alternatively the cover could have a number or fixed positions or only partially cover and/or uncover the exhaust pipe **26'''**. The controller **98** can be any form of motion inducing device, e.g. mechanically via a cam, an arm, or the like, or electronically, pneumatically, magnetically, or the like.

The controller **98** can be coupled to the cover **96** and removably coupled, e.g. magnetically, spring-loaded, interference fit, or the like, to the window **22'''** at a window coupling **97**. The controller **98** can release from the window coupling **97** when the window is opened or removed from a face of the fireplace. The cover **96** and/or controller **98** can be biased such that the cover **96** moves to the closed position when the controller **98** is released from the window coupling **97**. The cover **96** and/or controller **98** can be biased by a spring, or the like, to pivotably or laterally move into position over the exhaust outlet **95**. Thus, the exhaust outlet **95** can be automatically closed, or substantially sealed, upon opening or removal of the window **22'''**. This can facilitate moving the heating device to the vent free fireplace configuration.

In some embodiments, the cover **96** can be positioned by other automated, or automatic, means upon opening or removal of the window and/or door, which are known to those of ordinary skill in the art. In some embodiments, the controller **98** can be a spring loaded member in a compressed configuration with the window installed, thereby urging the cover **96** away from the exhaust; however, removal of the window uncompresses the spring and urges the cover **96** toward the exhaust **26'''**. In some embodiments, the controller **98** can be one or more arm members coupled to an interior surface of the combustion chamber, e.g. top, front, back, right side, left side, or the bottom of the combustion chamber. In some embodiments, the controller **98** can be a solenoid powered to prevent spring-biased movement of the cover **96** over the exhaust **26'''**, and upon loss of electricity the solenoid allows the spring-biased cover **96** to seal off the exhaust pipe **26'''** from the chamber.

The fireplace **10'''** can be modified from the direct vent configuration to the vent free configuration manually or automatically. In some embodiments, the exhaust cover can be moved to the closed position to close and seal the chamber exhaust, via any of the various means described above as well as similar or equivalent means not described. In the event of a loss of electricity, proper functioning of the fireplace electronic components may be prevented. For example, electronically controlled fuel valves, regulators, and/or circulation fans may not work. To maintain continued heat generation to a building interior, the direct vent fireplace **10'''** can be readily and safely converted to a vent free fireplace **10'''** by closing the cover **96** and opening the sealed face of the chamber **14'''**.

The fireplace **10'''** can include a door **92** disposed on the front face of the fireplace, coupled, in one embodiment, by at least one hinge **91**. The door **92** can include a frame disposed about a window **22'''**. The frame can be any suitable material, e.g. metallic, or the like. The window **22'''** can provide a clear visual of the flame, logs, or the like, disposed within the chamber and configured to provide a natural flame appearance. The door **92** can lockingly seal and engage the chamber **14'''**. The door can include a handle **94** that can control a locking, or latching mechanism, and provide a feature to securely and safely hold onto, or grab, the door **92** to open, close, or generally control the door.

The window **22'''** and/or door **92** can establish a sealed side face of the sealed combustion chamber **14'''** when the fireplace **10'''** is configured to operate as a direct vent heating device. In particular, the window **22'''** can establish the front side face of the fireplace. In some embodiments, the side of the fireplace **10'''** can be any face, or surface, of the fireplace that extends from the bottom to the top of the fireplace, or an intermediate portion thereof. In some embodiments, the window **22'''** can be removable to provide an open front face of the fireplace **10'''** and provide the heat transfer from the fireplace through the open face to the building interior, rather than, or in combination with, fan-driven forced ventilation. In some embodiments, the window **22'''** can be positioned on any face of the fireplace **10'''**, e.g. front, back, right, left, top, or bottom.

The window **22'''** can be a variety of different configurations, e.g. single piece, multi-piece, framed, with or without handles, or the like. The window **22'''** can be fabricated and have material characteristics similar to the windows **22**, **22'**, **22''** described above. In some embodiments, only a portion of the window **22'''** can be removed from sealed engagement with the fireplace front side face, or any face thereof. In some embodiments, the entire window **22'''** or a portion of the window **22''** can be completely removed from the face of the heating device, such that the window is either installed on the fireplace or not installed on the fireplace. In some embodiments, the window **22'''** can be removed from the door **92**. In some embodiments, the window, or portion thereof, is hingedly, such as by hinges **91**, or the like, coupled to the fireplace **10'''**, and can be rotated or pivoted about the coupling to disengage the sealed interface between the window and the fireplace **10'''** front face **17'**. The window can be pivotably controlled by a rotatable handle, much like a typical casement window device. The window can be slidably movable to open all or a portion of the fireplace face. In some embodiments, a multi-piece window can be rotated and folded away from the front face of the fireplace.

Though a window **22'''** is described above, it should be understood that a window is not required and that the window can be replaced with other structures, including heat radiating structures. Also, any part of the heating device **10'''** can be opened or removed to move the heating device **10'''** to the vent free configuration, so long as by so doing the combustion chamber is no longer sealed allowing the free exchange of air and exhaust between the combustion chamber and the interior room environment, or the environment where the heating device is located. For example, the heating device **10'''** can be a cast iron stove/fireplace or have the appearance of a cast iron stove/fireplace. In such an embodiment, it is unlikely that there will be a window, but a door may be located at the front face, or on another surface that can serve the same or similar purposes as the window described herein.

In some embodiments, opening the window or door can expose an inlet vent that was previously blocked to allow air to enter through the newly exposed and opened inlet.

In some embodiments, the fuel delivery system can include electronic controllers and/or electronic mechanisms, e.g. electronic regulator, valves, air shutter, or the like (not shown). The fuel delivery system components can be similar to the fuel delivery system **40** described above, or the systems and devices disclosed in the incorporated U.S. Pat. No. 7,434,447 and U.S. patent application Ser. No. 12/797,511. Upon loss of electricity, the electronic regulator, and/or fuel valve, can be configured to automatically shut down, or deactivate, to prevent accumulation of uncombusted fuel within the combustion chamber **14'''** should the flame at the burner **135'''** extinguish. In some embodiments, the electric valve assembly controlling direct vent combustion can become inoperable when electric power is lost to the fireplace **10'''**. In some embodiments, a loss of electricity to the fireplace **10'''** can render the unit useless as a heat source.

In some embodiments, the fuel delivery system can advantageously include a both a manual and an automatic control valve, where the control valve is used to control the amount of fuel flowing to the burner. The manual valve can be configured to provide less fuel to the burner and thereby provide a lower energy output as compared to the automatic control valve. The manual valve can be operated manually by a control knob on the fireplace **10'''**. The reduced energy, e.g. decreased BTU/hr output of the flame, or the like, can eliminate or reduce the volume of combustion air emissions emitted into the building interior and maintain safe air quality conditions, even with the combustion chamber exhaust outlet **95** covered, or closed, by the exhaust cover

96. In some embodiments, the burner and/or flame characteristics can be controlled by the first knob 131''' and/or the second knob 132'''.

In some embodiments, the coupling 97 can be part of a circuit, such that opening the window also opens the circuit. The circuit can be connected to the electronic powered automatic control valve which powers down when the circuit is opened. Fuel flow can then be directed to the manual valve operating at a lower BTU/hr rating. Alternatively, a button switch may be depressed or released when the window is opened or removed, thereby deactivating the automatic control valve.

In some embodiments, the fuel delivery system can advantageously include a second valve and/or other fuel system components (not shown), that can be manually opened, controlled, and ignited. The second valve can, either alone, or in combination with a second burner (not shown), provide a lower energy output. In some embodiments, the valve can be operated manually by a control knob 99 disposed on an outer surface of the fireplace 10'''. The reduced energy, e.g. decreased BTU/hr output of the flame, or the like, can eliminate or reduce the volume of combustion air emissions emitted into the building interior and maintain safe air quality conditions, even with the combustion chamber exhaust outlet 95 covered, or closed, by the exhaust cover 96. In some embodiments, the burner and/or flame characteristics can be controlled by the first knob 131''' and/or the second knob 132'''.

With reference to FIG. 12, the dual-function direct vent and vent free fireplace 10''' can further include one or more oxygen depletion sensors (ODS) 106. The ODS can include the various features and characteristics disclosed in U.S. Pat. No. 7,434,447 and U.S. patent application Ser. No. 12/797,511, incorporated by reference as described above. The ODS can include a pilot and a thermocouple arranged such that the flame from the pilot heats the thermocouple and the heat indicates oxygen levels, for example reduced oxygen levels can result in an extinguished pilot flame and decreased thermocouple temperatures. The oxygen depletion sensor can indicate when oxygen levels reach dangerous low levels. In some embodiments, the ODS can always be operational, for example, when the fireplace 10''' is operating in the direct vent mode and external ambient air provides the combustion air to the burner. In some embodiments, the ODS can become operational upon opening or removal of the window 22''' and the closure of the exhaust 26'''. The ODS can be particularly suitable for operation in embodiments whereby the external ambient air intake is closed in the vent free configuration.

In some embodiments, the fireplace 10''' can include multi-fuel capability, allowing the fireplace to operate on one fuel among a group of multiple types of fuel, e.g. natural gas, propane, or the like. Such a dual fuel configuration, described above, and further described in incorporated U.S. Pat. No. 7,434,447 and U.S. patent application Ser. No. 12/797,511, can provide a regulator configured to function within distinct pressure ranges, ranges that are typical of the proposed gases, or fuels, for the fireplace operation.

Turning now to FIGS. 14 and 15, the flow circulation path within the fireplace 10''' is shown for an embodiment of a direct vent configuration. The fireplace 10''' is shown with two circulation fans, a first fan 100 for a combustion vent system 90' and a second fan 86' for a heating air circulation system 80'. Together the two flow systems 80' and 90' can provide complete, or substantially complete, combustion and consistent heat transfer to the room interior where the fireplace 10''' is installed and functioning in a direct vent configuration.

The circulation flow path of the combustion vent system 90' is shown by the arrows depicted in FIG. 14. The combustion vent system 90' can include a combustion air intake 24''', an exhaust 26''', a combustion air channel 25, a baffle 102, and a combustion fan 100. The combustion system 90' can be configured similar to the systems and embodiments described above, bringing external ambient air from the air intake 24''', into the combustion chamber 14''' and then expelling the exhaust air out the exhaust 26''' to the external ambient environment. Thus, the interior air generally does not take part in the combustion process and can generally avoid being either the combustion air or mingling with the exhaust emission from the fireplace.

The combustion air intake and exhaust are desirably collinear as described above with respect to heating device 10''. The combustion air channel 25 can be a spaced gap between two panels of the chamber 14''', such as between an interior panel 34 and an exterior panel 36 that establish the outside boundary, or surfaces, of the sealed combustion chamber 14'''. The channel 25 desirably extends along a top portion of the chamber 14''', then down a rear portion of the chamber to the base of a floor. The channel 25 desirably exits to the burner 135''' at the bottom of the combustion chamber 14''', where the combustion air drawn into the chamber via the combustion fan 100 desirably is directed to the burner and to the window 22'''. The interior panel, or conduit panel 36, desirably can be parallel to the rear firebox panel 34 within the sealed combustion chamber 14'''.

The combustion fan desirably can be disposed within the combustion chamber 14''' to direct the incoming ambient combustion air toward the burner 135''' and the window 22'''. In some embodiments, the baffle 102 can be disposed adjacent the floor and can direct the combustion air toward the window 22''' and/or the burner 135'''. The use of combustion fan 100 to force combustion air toward the burner can increase, or improve, the mixing of fuel and combustion air thereby improving combustion characteristics at the burner flame. For example, improved combustion can result in cleaner combustion of the fuel and reduced air pollutants in the combustion emissions of the fireplace 10'''.

The combustion fan 100 can generally be positioned in any suitable arrangement within the chamber 14'''. In some embodiments, the combustion fan 100 can be positioned in a first ¼, ⅓, ⅔, the final ¼, ⅓, or any portion thereof, of the heating channel 25 flow path, or accordingly, of the floor portion of the heating channel 15'''. Similarly, the combustion fan 100 can be positioned in any portion of the channel 15''', e.g. a first ¼, ⅓, ⅔, the final ¼, ⅓, or any portion thereof, such that the air drawn into and blown out of the fan 100 is not substantially over-heated by the combustion in the sealed combustion chamber 14'''. In some embodiments, the combustion fan 100 can be located outside of the channel 15'''.

In some embodiments, ambient air can be drawn into the combustion fan 100 and directed to the window 22'''. As shown, the baffle 102 is angled with respect to the window 22 such that air directed at the baffle 102 will flow upwards towards the burner 135''' or towards the window 22'''. As can also be seen, a small gap is formed between the burner 135''' and the baffle 102. This small gap can direct air flow to the window 22'''. This air flow directed at the window can include ambient air at a lower temperature than the exhaust air. As will be understood, the lower portion of the window may be in close contact with the flames and heat from combustion at the burner **135'''**. Directing a flow of air at the lower portion of the window can help cool the window **22'''**.

The combustion airflow pushed by the combustion fan **100** can generally flow up substantially the full height off the window **22'''** on the chamber inside surface. In some embodiments, the combustion air can flow over a portion of the window **22'''** height, e.g. ¼, ½, ¾, substantially the entire height, or the like, up the window **22'''**. In other embodiments, the combustion air can flow over a portion of the window **22'''** after first flowing through cooling channels as described with reference to FIGS. **9-11**. The combustion fan **100** can be positioned within the sealed combustion chamber **14''** and generally upstream of the baffle **102**; thus, the combustion fan **100** can be located between the air intake **24'''** and the window **22'''**.

The circulation flow path of the fluid circulation system **90'** is shown by the arrows depicted in FIG. **15**. The fluid circulation system **90'** can include a vent inlet **13'''**, a heating channel **15'''**, a climate control outlet vent or exhaust **16'''**, and climate control fan **86'**. The fluid circulation system **80'** brings interior air into a flow path disposed about the combustion chamber **14'''**. Though the vent inlet **13'''** is shown on the top of the fireplace **10'''**, the vent inlet can function in a similar manner as those discussed previously, including vent inlet **13** shown in FIG. **1** to draw into the fireplace **10'''** to be heated within the fireplace.

Advantageously, the interior air can cool the rear firebox panel **34** surfaces of the fireplace **10'''** chamber, and cool the glass window **22'''** while at the same time absorbing heat energy and heating the air flow within the channel **15'''**, and then dispersing the heated air out of the fireplace to heat the room interior.

As can be seen, the window **22'''** can be a dual paned window having a first pane **93** and a second pane **95**. The second pane **95** can form part of the sealed chamber and can be closest to the burner **135'''**. The channel **15'''** can run between the two panes of window **22'''**, cooling the window and decreasing the burn risk and fire risk. Even when the fan **86'** is not on or running, the dual paned window creates an added barrier between the glass closest to the flames and the room interior. This barrier can also be effective to reduce the burn and fire risks.

The heating channel **15'''** can extend from the air vent inlet **13'''** disposed about the flue, or the combustion air intake **24'''** at a top portion of the heating device **10'''**, rearward between the top portion of the fireplace and the top portion of the chamber **14'''**. The channel **15'''** then progresses downward and behind the rear firebox panel **34** of the chamber **14'''** to the volume underneath the floor. The channel **15'''** then proceeds from under the floor through the space gap between the two panes **93**, **95** of the dual paned window **22'''** on the door **92**. The heating channel **15'''** can vary according to suitable geometry, and can take any form set forth above. It can also comprise multiple cooling channels along the front face, as described with reference to FIGS. **9-11**. The interior air exchanges heat from the chamber **14'''** generally continuously as the air travels through the at least three portions (rear, bottom, front) of the channel **15'''**. In particular, the heating air forced through by the climate control fan **86'** can cool the front face window **22'''** to prevent the surface from becoming excessively hot during use of the fireplace **10'''**.

The climate control fan **86'** can be disposed in the heating channel **15'''**. The fan **86'** draws interior air into the fireplace through the air vent inlet **13'''**. The fan **86'** can have the various characteristics described above with respect to cooling fan **82** and/or climate control fan **86**.

The climate control fan **86'** can generally be positioned in a first half, or a first two-thirds, of the channel **15'''** extending from the air inlet vent **13'''**. As described above, the channel **15'''** can define a flow path from the top surface of the fireplace **10'''**, down the back side of the chamber **14'''**, and under the floor of the combustion chamber **14'''** to the window **22'''** between the first pane **93** and the second pane **95**, then out the outlet vent **16'''**.

In some embodiments, the climate control fan **86'** can be positioned in a first ¼, ⅓, ⅔, or any portion thereof, of the channel **15'''** flow path. Similarly, the climate control fan **86'** can be positioned in any portion of the channel **15'''** such that the air drawn into and blown out of the fan **86'** is not substantially over-heated by the combustion in the sealed combustion chamber **14'''**. In some embodiments, heated air can be drawn into the climate control fan **86'** and directed to the window **22'''**. In some embodiments, the climate control fan **86'** can be located outside of the channel **15'''**.

Although this invention has been disclosed in the context of certain preferred embodiments and examples, it will be understood by those skilled in the art that the present invention extends beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the invention and obvious modifications and equivalents thereof. In addition, while a number of variations of the invention have been shown and described in detail, other modifications, which are within the scope of this invention, will be readily apparent to those of skill in the art based upon this disclosure. It is also contemplated that various combinations or subcombinations of the specific features and aspects of the embodiments may be made and still fall within the scope of the invention. Accordingly, it should be understood that various features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes of the disclosed invention. Thus, it is intended that the scope of the present invention herein disclosed should not be limited by the particular disclosed embodiments described above, but should be determined only by a fair reading of the claims that follow.

Similarly, this method of disclosure, is not to be interpreted as reflecting an intention that any claim require more features than are expressly recited in that claim. Rather, as the following claims reflect, inventive aspects lie in a combination of fewer than all features of any single foregoing disclosed embodiment. Thus, the claims following the Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment.

What is claimed is:

1. A heating apparatus comprising:

- a sealed combustion chamber, having a front face viewable to a user when the heating apparatus is in use;
- a burner disposed within said combustion chamber;
- a combustion air inlet in fluid communication with the sealed combustion chamber and configured to provide air to the burner;
- an exhaust air outlet in fluid communication with the sealed combustion chamber and configured to remove exhaust air from the combustion chamber;
- an outer housing surrounding at least a portion of the sealed combustion chamber;
- a system of channels comprising at least two of a top channel above the front face, a left side channel to the left of the front face, a right side channel to the right of the front face, and a bottom channel below the front

face, said at least two of said channels configured to direct air to the front face of the sealed combustion chamber,

wherein the at least two channels comprise the bottom channel configured to direct air generally upward, both along the front face and into at least one other channel, the bottom channel having a plurality of outlets comprising a center outlet directing air generally upward along the front face and side outlets that also direct air generally upward along the front face, the side outlets being smaller than the center outlet;

at least one fan positioned within the outer housing and configured to direct air into the system of channels; and

a control module coupled to the burner and the at least one fan, the control module configured to activate the at least one fan when the burner is in operation.

2. The heating apparatus of claim **1**, further comprising a window located behind and substantially parallel to the front face, defining a cooling space between the window and the front face that is located in front of the sealed combustion chamber.

3. The heating apparatus of claim **2**, wherein the system of channels is located such that air exiting the system of channels exits into the cooling space.

4. The heating apparatus of claim **1**, wherein the center outlet is larger than any other outlet in the system of channels configured to direct air onto the front face.

5. The heating apparatus of claim **4**, wherein the side outlets comprise two sets of outlets positioned at an angle from the center outlet and configured to direct air generally upward and to a center of the front face.

6. The heating apparatus of claim **1**, wherein the side outlets comprise two sets of outlets positioned at an angle from the center outlet and configured to direct air generally upward and to a center of the front face.

7. The heating apparatus of claim **1**, wherein the control module is configured to deactivate the burner when the control module receives an input, or a lack of an input, indicating that the cooling fan is not functioning properly.

8. The heating apparatus of claim **1**, wherein the control module is configured to cause the at least one fan to remain activated for a period of time after the burner is deactivated.

9. The heating apparatus of claim **1**, further comprising a thermocouple positioned proximate to the front face and configured to sense a temperature of the front face, the thermocouple coupled to the control system such that the control system is configured to cause the at least one fan to remain activated after the burner is deactivated until the front face is cooled to a predetermined temperature.

10. A heating apparatus comprising:

a sealed combustion chamber, having a front face viewable to a user when the heating apparatus is in use;

a burner disposed within said combustion chamber;

a combustion air inlet in fluid communication with the sealed combustion chamber and configured to provide air to the burner;

an exhaust air outlet in fluid communication with the sealed combustion chamber and configured to remove exhaust air from the combustion chamber;

an outer housing surrounding at least a portion of the sealed combustion chamber;

a system of channels comprising at least two of a top channel above the front face, a left side channel to the left of the front face, a right side channel to the right of the front face, and a bottom channel below the front face, said at least two of said channels configured to direct air to the front face of the sealed combustion chamber,

wherein the at least two channels comprise a bottom channel configured to direct air generally upward, both along the front face and into at least one other channel, the bottom channel having a plurality of outlets comprising:

a center outlet directing air generally upward along the front face; and

two sets of side outlets positioned at an angle from the center outlet and configured to direct air generally upward and to a center of the front face;

at least one fan positioned within the outer housing and configured to direct air into the system of channels; and

a control module coupled to the burner and the at least one fan, the control module configured to activate the at least one fan when the burner is in operation.

11. The heating apparatus of claim **10**, wherein the system of channels comprises a plurality of air outlets through which air exits the system of channels.

12. The heating apparatus of claim **11**, wherein the center outlet is larger than any of the other air outlets of the plurality of air outlets in the system of channels configured to direct air onto the front face.

13. The heating apparatus of claim **10**, further comprising a window located behind and substantially parallel to the front face, defining a cooling space between the window and the front face that is located in front of the sealed combustion chamber.

14. The heating apparatus of claim **13**, wherein the system of channels is located such that air exiting the system of channels exits into the cooling space.

15. The heating apparatus of claim **10**, wherein the control module is configured to deactivate the burner when the control module receives an input, or a lack of an input, indicating that the cooling fan is not functioning properly.

16. The heating apparatus of claim **10**, wherein the control module is configured to cause the at least one fan to remain activated for a period of time after the burner is deactivated.

17. The heating apparatus of claim **10**, further comprising a thermocouple positioned proximate to the front face and configured to sense a temperature of the front face, the thermocouple coupled to the control system such that the control system is configured to cause the at least one fan to remain activated after the burner is deactivated until the front face is cooled to a predetermined temperature.

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